Announcement of the

College of Engineering

including

THE SCHOOL OF CIVIL ENGINEERING
THE SIBLEY SCHOOL OF MECHANICAL ENGINEERING
THE SCHOOL OF ELECTRICAL ENGINEERING
THE SCHOOL OF CHEMICAL ENGINEERING
THE COURSES IN ADMINISTRATIVE ENGINEERING

for the Academic Year

1942-43

The University Calendar for 1942-43

	1942	FALL TERM
Sept.	9–10, *Wed.-Thurs.*,	Entrance examinations.
Sept.	25, *Friday*,	Orientation Meetings. Physical examinations begin.
Sept.	28, *Monday*,	Registration and assignment, new students.
Sept.	29, *Tuesday*,	Registration and assignment, old students.
Oct.	1, *Thursday*,	Instruction begins at 8 A.M.
Oct.	22, *Thursday*,	Last day for the payment of tuition for the fall term.
Nov.	26, *Thursday*,	*Thanksgiving Day*, a holiday.
Dec.	19, *Saturday*,	Instruction suspended at 12:50 P.M.
	1943	*(Christmas Recess)*
Jan.	4, *Monday*,	Instruction resumed at 8 A.M.
Jan.	11, *Monday*,	Founder's Day.
Jan.	21, *Thursday*,	Final examinations begin.
Jan.	28, *Thursday*,	Final examinations end.
		SPRING TERM
Jan.	29, *Friday*,	Registration of all students.
Feb.	1, *Monday*,	Instruction begins at 8 A.M.
Feb.	22, *Monday*,	Last day for the payment of tuition for the spring term.
March	27, *Saturday*,	Instruction suspended at 12:50 P.M.
		(Spring Recess)
April	5, *Monday*,	Instruction resumed at 8 A.M.
May	17, *Monday*,	Final examinations begin.
May	22, *Saturday*,	Final examinations end.
May	24, *Monday*,	COMMENCEMENT.

CORNELL UNIVERSITY OFFICIAL PUBLICATION

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Contents

NOTICE

This publication discusses only the *normal* programs of instruction offered by the College of Engineering. These programs are similar to those followed heretofore.

The wartime *accelerated programs*, with graduation advanced ahead of normal, are described in a separate pamphlet which is obtainable from the Dean of the College of Engineering.

Students in Engineering may pursue either the normal or the accelerated programs; and they may transfer from the one to the other.

The College of Engineering

ITS HISTORY AND ORGANIZATION

Engineering has had an important place in the program of Cornell University from the beginning. The Federal Land Grant, or Morrill, Act of 1862, which supplied a considerable proportion of the University's original endowment, specified that a leading object of the institution should be to teach "such branches of learning as are related to . . . the mechanic arts"; and this provision was in perfect accord with the ideals of the founder and of the first president. Both Ezra Cornell, the practical man of affairs, who had amassed a fortune in the Western Union Telegraph Company, and Andrew D. White, the brilliant scholar and educator, who had carefully analyzed contemporary higher education in America and in Europe, believed in the equal dignity of scientific and classical studies and determined to put the practical arts, such as engineering, on the same plane with the humanities. This program was considered revolutionary when announced at the University's opening in 1868. That it has since been generally adopted by American universities indicates the soundness of the basic Cornell idea that instruction in engineering should be given on a high professional level. The College of Engineering still adheres firmly to this policy.

Mechanical engineering and civil engineering have been strong divisions of the University since its foundation. The first was originally called the College of Mechanic Arts and later the Sibley College of Mechanical Engineering and Mechanic Arts, in recognition of munificent gifts by Hiram Sibley, founder of the Western Union Telegraph Company, and his son, Hiram W. Sibley. Civil Engineering, originally a separate school in the College of Mathematics and Engineering, and later the College of Civil Engineering, has also retained its identity to the present day.

In 1883 Cornell opened courses in electrical engineering, among the first to be offered anywhere in America; and in 1919, when the Board of Trustees formed the present College of Engineering, the School of Electrical Engineering was established as one of the three component units, on a par with the Sibley School of Mechanical Engineering and the School of Civil Engineering.

The College of Engineering organized a five-year course in Chemical Engineering in 1931; and seven years later the School of Chemical Engineering was established to supervise the curriculum which

leads to the degree of Bachelor of Chemical Engineering. Four-year courses leading to the degree of Bachelor of Science in Administrative Engineering in civil, mechanical, and electrical engineering were introduced in 1931.

Students in Engineering at Cornell use the facilities of the several Sibley buildings which house the Sibley School of Mechanical Engineering; Lincoln Hall which is devoted to the School of Civil Engineering; Franklin Hall which contains most of the School of Electrical Engineering; Rand Hall, the gift of Mrs. Florence O. R. Lang, in which are located the Machine Shop, Pattern Shop, and senior Electrical Laboratory; the Hydraulic Laboratory on Beebe Lake above Triphammer Falls; and Olin Hall of Chemical Engineering, recently given by Franklin W. Olin to provide most adequately for the School of Chemical Engineering. For various preparatory and elective courses they also use the facilities of the Baker Laboratory of Chemistry, a building given to the University in 1922 by George F. Baker; and those of Rockefeller Hall, erected by John D. Rockefeller for the Department of Physics; and other buildings and equipment available in the College of Arts and Sciences.

Cornell engineers enjoy all the benefits and privileges of an outstanding university community. They associate continually, in fraternities and dormitories, in extra-curricular activities, and in general University functions, with students of liberal arts, agriculture, law, veterinary medicine, and architecture. Concerts by world-famous soloists and orchestras, lectures by renowned scholars in widely varying fields, dramatic productions, and art exhibits add to the cultural atmosphere in which Cornell engineers move as undergraduates.

These facts, in addition to the beauty of the Campus and the surrounding Finger Lakes region and the consideration that Ithaca is a small city, removed from the distractions of a metropolitan area but easily accessible by railroad and highway, help to explain the composition of the student population, which each year includes students from every part of the United States and numerous foreign countries.

The College of Engineering now comprises the School of Civil Engineering, the Sibley School of Mechanical Engineering, the School of Electrical Engineering, and the School of Chemical Engineering. Courses in Administrative Engineering are given in the first three of these Schools. Graduate instruction in engineering is offered by the Engineering Division of the Graduate School of the University.

PURPOSE OF THE INSTRUCTION

Engineering education at Cornell is broadly professional, designed to train men for leadership in public service, business, and industry. In the opinion of the Faculty, confirmed by representatives of concerns employing the bulk of engineering graduates, technical competence in the general field of engineering is essential to success even in the narrower specializations, such as radio, aeronautics, and air-conditioning, and time spent on fundamentals shortens the period of adjustment during which the graduate engineer discovers the specialty he is best fitted to pursue. Hence the College emphasizes instruction in the basic principles and applications of science, and offers specialized options only to a limited extent.

Experience has demonstrated that the secondary school student often lacks the ability to anticipate with accuracy the type of work for which he will ultimately find himself best adapted. Some of the largest industries, which offer the widest variety of opportunity within their own organizations, consider it necessary to observe even the engineering graduate for at least a year before deciding to what division of the company he should be assigned. Their records contain many instances of men who originally desired to become air-conditioning experts or airplane designers but eventually applied their personal aptitudes most successfully in such fields as power-plant management or metallurgical research.

Furthermore, a successful career is a record of competence in a series of situations actually available. No student can be certain that he will be offered precisely the employment that he desires at the time he graduates. Nor, in these times of rapid advances in technology, can he be sure that such a situation, if offered, would be a step along the road to the highest achievement of which he is capable. In electrical engineering, for instance, the full effect of the vacuum tube is as yet unknown, but this invention has already required not only a modification of existing electrical machines, but also an entirely new theoretical approach. Similar developments have taken place and will continue in the fields of mechanical, civil, and chemical engineering. Like the village blacksmith, the narrow specialist in engineering may one day find his specialty no longer in demand. Only a broad and intensive training in the fundamental sciences can fit an engineer to take advantage of new opportunities as progress in industry creates them.

Just as the modern engineer needs broad and deep scientific training, he also must have a working knowledge of the social and

economic structure. He can no longer act as an isolated technician; he must become an effective part of the society in which he lives, able to see the results of his efforts in relation to the industrial and social system as a whole. Unemployment, the standard of living, mass prejudices, political programs—all affect him not only as a person but also as an engineer. Such factors have constantly increasing significance in any program of public works or industrial development, and the engineer must understand them in order to solve his professional problems.

These considerations explain certain general features of the courses of study offered by the College. In the Schools of Civil, Mechanical, and Electrical Engineering, the freshman programs have been made nearly uniform, so that, if necessary, the student may have an additional year after his admission to discover in which of these general fields his best work can be accomplished, and may then change his course and still, by taking work in the summer session, graduate with his class. In all the schools, specialization has been postponed until late in the course and is limited both in character and in extent; and opportunities have been made for required and elective courses in such fields as physical science, social studies, and written and spoken English.

Dominant in all the courses of study is instruction designed to teach the fundamental principles, theoretical and practical, that underlie the various branches of engineering. Classroom instruction and laboratory experiment are supplemented by experience with the operation of various kinds of apparatus in the College laboratories and shops and by trips to inspect manufacturing plants, public works, and other places of interest in the industrial centers of the East. The student thus becomes familiar with problems encountered in modern engineering and with practical methods for their solution.

The basic purpose of the entire program is to make adjustment easier for the graduate when he begins actual engineering work, and to fit him for leadership in his profession.

THE ORGANIZATION FOR INSTRUCTION

It has been said that engineering has more major divisions than any other profession; and each of these main divisions has many special branches. For effective instruction, the College of Engineering is divided into schools representing the four main divisions, Civil, Mechanical, Electrical, and Chemical Engineering, each with a director and a separate faculty. Administrative Engineering, designed to train men

in engineering and in the allied fields of industrial management, is offered in special groups of courses in the Schools of Civil, Mechanical, and Electrical Engineering.

The faculties of the schools are further divided into departments with staffs of specialists in their respective branches. Since the character of all instruction depends primarily on the qualifications of the teaching staff and on the efficiency with which knowledge is imparted to their students, careful consideration has been given to the type of men chosen for the faculty, to their number in relation to student enrollment, and to the facilities needed to make their instruction most effective.

Faculty members are selected for their scientific training, their teaching ability, and their practical knowledge of and close contact with modern engineering problems and procedures. For many years the College has maintained a ratio between staff members and students of approximately one to ten, so that instruction may be given in small groups. The College is large enough to permit each course to be taught by specialists, and yet not so large that the student fails to receive the personal attention of his instructors. The extensive laboratories and other facilities for instruction, both fundamental and advanced, are described elsewhere in this Announcement.

DEGREES OFFERED Cornell University confers the following degrees on the successful completion of undergraduate courses of study in the College of Engineering: Bachelor of Civil Engineering (B.C.E.), Bachelor of Mechanical Engineering (B.M.E.), Bachelor of Electrical Engineering (B.E.E.), Bachelor of Science in Administrative Engineering (B.S. in A.E.), and Bachelor of Chemical Engineering (B. Chem. E.).

By fulfilling additional requirements (see page 13) graduates become eligible for the professional degrees of Civil Engineer (C.E.), Mechanical Engineer (M.E.), Electrical Engineer (E.E.), and Chemical Engineer (Chem. E.).

The advanced degrees of Master of Chemical Engineering (M. Chem.E.), Master of Civil Engineering (M.C.E.), Master of Electrical Engineering (M.E.E.), Master of Mechanical Engineering (M.M.E.), Master of Science in Engineering (M.S. in Engineering), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) are granted by the University on the recommendation of the Faculty of the graduate School. (See page 13).

FOUR-YEAR COURSES The four-year courses offered in the College lead to the degree of B.C.E., B.M.E., B.E.E., and B.S. in A.E. respectively. Later in this Announcement there will be found, under the appropriate heads, detailed statements of these courses. In the last year of each course, certain options or electives are offered, so that each student may have a certain amount of freedom in placing the main emphasis of his work upon branches of the profession in which he may be most interested. These options and the elective courses are clearly defined in the announcement of each school on subsequent pages.

FIVE-YEAR COURSES The course of study leading to the degree of Bachelor of Chemical Engineering consists of an integrated five-year program in which provision is made for a considerable amount of elective work.

Five-year courses leading to the single degree of B.C.E., B.M.E., B.E.E., or B.S. in A.E. consist of the four-year engineering courses of study modified by the introduction of the equivalent of one year of broadening training. The entrance requirements are those of the four-year courses. There are no regular schedules for these five-year courses, the student being referred to the director of the school concerned for the arrangement of studies at the beginning of each term.

It is possible to rearrange the required work in the respective four-year courses of study in mechanical and electrical engineering so that both the B.M.E. and B.E.E. degrees may be obtained in a five-year period of study. The necessary adjustment of work for this purpose must be made with the directors of the Schools of Mechanical Engineering and Electrical Engineering before the beginning of the student's second year. For a suggested plan, see page 142.

In administrative engineering it is possible so to arrange the work of the five-year course that the degree of B.C.E., B.M.E. or B.E.E. is obtained at the end of the first four years and the degree of Bachelor of Science in Administrative Engineering at the end of the fifth year. Declaration of intention to take these five-year combinations should be made before the beginning of the student's second year.

SIX-YEAR COURSES The six-year courses leading to the degrees of A.B. and B.C.E., or A.B. and B.M.E., or A.B. and B.E.E., or A.B. and B.S. in A.E., require admission to the College of Arts and

Sciences, in which college the student is registered during the first four years. In order to make it possible to obtain the B.C.E., B.M.E., B.E.E., or B.S. in A.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects before the beginning of his fourth year, and must complete the list of sophomore subjects in civil engineering, mechanical engineering, or electrical engineering before the beginning of his fifth year. Advice and assistance in arranging such a course may be obtained by applying to the director of the school concerned. (For outlines of suggested six-year courses of study, see pages 71, 114, and 144.)

GRADING SYSTEM

Scholastic grading in the College is on a numerical scale of 0 to 100 with 60 as passing. A mark of from 50 to 59 in a course means that the course has been conditioned; and a mark of 49 or below constitutes a failure in the course. A condition may be removed by passing a make-up examination, or by doing such additional work in the course, as may be prescribed by the department concerned, or the student may repeat the course in class. A failure may be removed only by repeating the course or such parts of it as may be directed.

The standing or rank of a student in his class is determined by his weighted average, which is computed from the credit hours and grades reported for all of his courses. The method of computing this average is described in the "Book of Rules" of the College of Engineering, available to all engineering students.

SCHOLASTIC REQUIREMENTS

In the Schools of Civil, Electrical, and Mechanical Engineering a student who does not receive a passing grade in every course in which he is registered, or who fails, in any term or summer session, to maintain an average of 65 per cent or better, with at least half the credit hours with marks of 70 per cent or better, may be dropped from the University, or placed on probation.

A student in the School of Chemical Engineering who does not receive a passing grade in every course for which he is registered, or who fails in any term or summer session to maintain an average grade of 75 per cent may be dropped or placed on probation.

If in the opinion of the Faculty of the School concerned, a student's general record is unsatisfactory, the student may be refused permission to continue his course even though he has met the minimum

requirements in respect to the number of hours of work passed and the grades in those hours. Students who fall behind in their work may be warned, put on probation, or dropped, either from an individual course, or from the University at any time during the term.

THE REQUIREMENTS FOR GRADUATION

The degrees of B.C.E., B.M.E., B.E.E., B.S. in A.E., or B. Chem.E., are conferred on candidates who have fulfilled the following requirements:

1. The candidate must have been in residence and registered in the College of Engineering for the last two terms and must have satisfied the University requirements in Military Science and Tactics (or Physical Education), in Hygiene, and in the payment of tuition and fees.

2. He must have completed to the satisfaction of the Faculty of the College of Engineering all the subjects, and the elective hours, prescribed in the course of study as outlined by that faculty.

3. A student who transfers to the College of Engineering, after having spent one or more terms in another college of Cornell University or elsewhere, must conform to the requirements of the class with which he graduates.

UNIVERSITY REQUIREMENTS

MILITARY SCIENCE

Cornell University requires men of the Freshman and Sophomore classes to take the Basic Course in Military Science and Tactics. That requirement is precisely defined, and exceptions and alternatives are clearly stated, in the *General Information Number*, which should be consulted. See also page 163 of this Announcement.

HYGIENE

The University requires all members of the Freshman class to take a course of one hour a week in Hygiene and Preventive Medicine, and requires every student to take a physical examination in the Freshman and again in the Senior year. See page 162 and the *General Information Number*.

ONE DEGREE IN ANY YEAR

If a person has satisfied the requirements for any baccalaureate degree, he may not be recommended for any other baccalaureate degree until he has completed at least one year of further residence and of work acceptable to the

faculty on whose recommendation the second baccalaureate degree is to be conferred.

PROFESSIONAL DEGREES The degrees of Civil Engineer, Mechanical Engineer, Electrical Engineer, and Chemical Engineer, which were formerly conferred at the end of undergraduate courses, are now designated as professional degrees and hereafter will be conferred only on graduates who have been successful in the actual practice of their profession and who meet certain other requirements.* The deferred professional degrees of C.E., M.E., E.E., and Chem.E., may be awarded under the following regulations:

(a) Applicants must hold baccalaureate degrees given by this College. Applications for these degrees should be sent to the Dean of the College at least one year before the time the degree is desired.

(b) Each applicant for one of these professional degrees must have had after baccalaureate graduation four years of acceptable professional experience in the field of the degree sought. Each year of graduate residence credit in this field at Cornell or at some other accredited Graduate School, or each year of teaching in that field at Cornell or in any college of comparable rank may be counted as one year towards satisfying the requirement of professional experience. Detailed statements regarding his professional experience must be submitted by persons, firms, or colleges under whom the experience was acquired.

(c) The applicant must write and present an original thesis of a type which would be accepted as a technical paper by one of the professional engineering societies. Detailed information regarding the proposed thesis must be submitted, in duplicate, preferably before the writing of the thesis is undertaken. The thesis must be submitted in triplicate to the Dean of the Engineering College three months prior to the June Commencement, and must conform to the requirements of the Graduate School relating to theses.

(d) The applicant must present himself at the University for an examination by a Faculty Committee. Such examination may be written, or oral, or both, and cover both the subject matter of the thesis and the professional experience. The candidate must pay such fees as may be required by the Treasurer of the University.

REQUIREMENTS CHANGEABLE The College of Engineering reserves the right to modify its general courses of study and specific courses of instruction, to alter the requirements for admission or for graduation, and to change the degrees to be awarded, and such changes are applicable to either prospective or matriculated students at any such time as the college may determine.

GRADUATE STUDIES Graduates of this College or of other colleges of engineering may enter the Graduate School of Cornell University and pursue advanced work in engineering. Such a student may enter either as a candidate for a degree (M.C.E., M.M.E.,

*Undergraduates who matriculated in the five-year course in Chemical Engineering before June 1, 1938, have the choice between the degree of Chemical Engineer and the degree of B.Chem.E.

M.E.E., M.Chem.E., M.S. in Engineering, M.S., or Ph.D.) or without candidacy for a degree, according to the character of his previous training. A prospective graduate student should consult the *Announcement of the Graduate School* and apply to the Dean of the Graduate School. Information concerning graduate scholarships and fellowships, including the John McMullen Graduate Scholarships, can be obtained either from the Dean of the Graduate School or from the Dean of the College of Engineering.

PERSONNEL SYSTEM The College of Engineering operates a personnel system to aid the student in deciding the nature of the work for which he is best suited. It endeavors to point out his desirable as well as his undesirable characteristics with a view to correcting the latter if possible. During the first and second years the student is rated by his instructors. In the third and fourth years he is rated by a committee of five members of the faculty and five members of his own class whom he has selected as being especially capable of giving him an accurate rating. The complete rating is compiled by the personnel officer and given to the student for his guidance. By this system there is available to every student information that he could not obtain otherwise and which should be of great value to him in laying part of the foundation for a successful career. In each of the four Schools a member of the faculty has been assigned as personnel officer. The personnel officer acquaints himself with the desirable and undesirable traits of each student as indicated by the composite rating; points out to the student the advantages of carefully developing his desirable traits; and advises the student which of the undesirable traits may be changed. With such advice the student is in a position, during the highly formative period of his life, to develop the characteristics which will aid him materially in later life. During the senior year each student is interviewed and an analysis of his aptitudes is made in order that he may intelligently consult with representatives of business and industry.

EMPLOYMENT PROGRAM A systematic effort is made by the College of Engineering to help every graduate find congenial employment. Each School maintains an employment bureau under the supervision of the Director. These bureaus are coordinated through the office of the Dean and are also in close touch with the University's own placement bureau.

A Five-Year Service Plan for graduates is also maintained, under which the members of each class are circularized at the beginning of

each year for five years after graduation to learn of their work, success, and desires as to change in position. After that period, those desiring changes of employment are urged to keep in touch with the Employment Bureaus in their respective Schools. Graduates frequently are enabled to make desirable connections through having up-to-date information regarding themselves on file in the College.

EXPERIMENT STATION The Engineering Experiment Station was established for the purpose of conducting scientific and technical research of importance to the engineering profession and to industries. The station affords opportunities for members of the faculty, graduate scholars, and selected undergraduates to use for that purpose not only the College's own facilities but also those of other departments of the University. The investigations may consist of analytical studies to develop new theories, laws, or concepts, or to interpret and make more useful information and data already available; they may consist of the design and construction of new and useful forms of apparatus; or they may be experimental investigations of materials and their properties or of structures, instruments, apparatus, machines, prime movers, air-conditioning equipment, heat-transfer apparatus, hydraulics, electronics, ultra-high-tension phenomena, mechanics of engineering, highway engineering, sanitary engineering, etc. New equipment is bought or constructed as needed.

In laboring to advance the science or the art of engineering the Experiment Station gives the members of the teaching staff a ready means of keeping abreast of the times and serves also as a stimulus to inquiring students. All members of the faculty are encouraged to use the station's facilities in their own research or in supervising that of the John McMullen Graduate Scholars and other advanced students.

The Dean of the College is director of the Experiment Station and chairman of a managing council which includes the Directors of the four Schools and a committee on research assisting each of the four. The station publishes bulletins giving reports of completed investigations.

Funds for the Experiment Station's work are derived from direct appropriation by the University and also from the income of special endowments. The *Harold I. Bell Research Fund* of $5,000 was established in 1922 by Mrs. Ellen Foster Bell in memory of her husband, a member of the Class of 1905, for the promotion of research in hydraulic engineering and related fields. The income of the *Henry Herman Westinghouse Endowment Fund* of $500,000, given by the late H. H.

Westinghouse of the Class of 1872 and established in 1933, is devoted, in accordance with the donor's wish, to the advancement of the science of engineering by means of research.

In addition to the investigations permitted by the Experiment Station's own funds the station or the college conducts *cooperative research*. This is done for companies or associations in trade or industry or for government bureaus. It involves experiment work for which there are facilities here and which is financed, at least in part, by those sponsoring the work.

THE ENGINEERING COLLEGE COUNCIL

The Engineering College Council consists of the President of the University, the Dean of the College, and a group of distinguished engineers, usually alumni, approved by the Board of Trustees of the University. The duties of the Council are to become thoroughly acquainted with the affairs of the College, to advise the administration and the Board of Trustees with regard to policies and programs designed to increase the efficiency of the established operations, to add to the available resources, to improve public and alumni relations, or in any other way to strengthen the College's work.

MISCELLANEOUS INFORMATION

Facilities available. In addition to the various school and departmental libraries of the College, the Cornell University Library is available to engineering students. This library contains one of the largest working collections of its kind in the country. Mathematics is taught in White Hall, adjacent to the Engineering College buildings. Instruction in physics is given in nearby Rockefeller Hall, a large and well equipped building used solely for work in this field. This building also houses the library of the Department of Physics. Instruction in chemistry is given in the Baker Laboratory of Chemistry, a commodious modern building with excellent facilities, including the library of Chemistry. Many other University buildings are used by students taking elective courses, or required courses in English, economics, and other non-technical subjects.

Nonresident Lecturers. Supplementing the regular class-room instruction, lectures are delivered from time to time by non-resident specialists in the profession on various subjects related to the many branches of engineering. Students may attend also the many public scientific

lectures given in other departments of the University by local or non-resident lecturers.

Inspection Trips. At appropriate times during their course the students of the various schools are taken on supervised inspection trips for the purpose of studying commercial, industrial, and engineering applications of the principles inculcated in the class-room, and affording them opportunities to observe typical engineering projects in the actual processes of development, as well as important ones that have been completed.

Dean's Honor List. Students of the College of Engineering whose weighted average in their studies is 85 per cent or better are included annually in an Honor List compiled for the Dean, who makes a public announcement of the names of those students at an event known as "Honor Night" which the College holds in the spring of each year. The honor students comprise approximately the highest tenth of all the students enrolled in the college.

Student Activities. Students of the College of Engineering find many opportunities of engaging in wholesome activities outside their regular duties, and even outside the College, in company with members of the University generally. Within the College some find congenial occupation in helping to carry on the student branches of the national engineering societies, in conducting *The Cornell Engineer*, or in membership in national or local honor societies, which include Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Chi Epsilon, Rod and Bob, Pyramid, Atmos, Kappa Tau Chi, and Eta Kappa Nu. In the University at large there are student activities of all sorts, musical, dramatic, journalistic, social, and athletic.

Engineering Societies. The College of Engineering is closely associated with the Ithaca Sections of the American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers, many of the meetings of which are held on the campus and are participated in by the members of the College. The College also maintains active student branches of these national societies as well as of the American Institute of Chemical Engineers. Their meetings are addressed by engineers of eminence, or are used for the presentation of papers by students, or for discussion, or for contests in public speaking on engineering subjects. The Schools of Mechanical and Electrical Engineering give elective credit hours for activity in the student branches of their respective engineering societies.

The Cornell Engineer, a technical journal published monthly through-

out the academic year, is managed and edited by undergraduates in the College of Engineering. Elective credit is given for work on this magazine. (See page 162.)

Student Counselors. In each of the Schools the students have the assistance of a special corps of Class Advisers in the planning and scheduling of their academic work. Also the students are free to consult with the Dean, Directors, Department Heads, and the Instructors not only on matters pertinent to their education and future plans, but also on personal matters. In addition, the University's Counselor of Students for men and his staff may be consulted by men students regarding their non-academic problems. There is also a Counselor of Students for women.

Assistance to Foreign Students. The University maintains on its staff a Counselor to Foreign Students, whose duty is to look after the welfare of all students from other countries. He may be consulted on personal problems, social questions, or any other matter in which he may be helpful. His office is in the Cornell Cosmopolitan Club, 301 Bryant Avenue, which has living and dining room accommodations for a group of foreign and American students. It is suggested that all foreign students write him before coming to Ithaca, or call on him immediately upon arrival. He will be glad to meet foreign students at the train, help them find suitable living quarters, either at the Club or elsewhere, and introduce them to other University officials, members of the faculty, and other students.

School of Civil Engineering

EQUIPMENT The principal building occupied by the School of Civil Engineering is Lincoln Hall, containing classrooms, drafting rooms, laboratories, museums, and the working library. The library facilities include the Kuichling Memorial Library donated and endowed by Mrs. Sarah L. Kuichling in memory of Emil Kuichling, A.B., C.E. The Irving Porter Church Fund, donated by former students of the School, aids in purchasing books.

The Highway Laboratories are housed in separate buildings and are equipped for making the standard tests and for research in the field of highway engineering. Astronomical equipment in the Fuertes Observatory includes the instruments required for determining time, latitude, longitude, and azimuth.

A large and unusual Hydraulic Laboratory, situated at the outlet of Beebe Lake, is under the jurisdiction of this School. In addition to student instruction and research, this laboratory provides facilities

for numerous important hydraulic investigations carried on in cooperation with governmental agencies and private companies.

The laboratories in Lincoln Hall are as follows: the Testing Laboratory, equipped for a wide variety of tests of cement, concrete, timber, structural steel, and other construction materials used by civil engineers; the Mechanics Laboratory, equipped for demonstration and experimentation in connection with the undergraduate instruction in mechanics; the Laboratory of Applied Elasticity, equipped for experimentation by advanced students; the Sanitary Laboratory, with facilities for physical, chemical, bacteriological, and biological analyses of water and sewage; and the Soil Mechanics Laboratory, with all the facilities for performing standard tests on soil. Further investigations in soil mechanics are carried on cooperatively by the School staff and the Army Engineers in another laboratory housed in a separate building constructed on the Campus by the Federal Government.

OUTLINE OF THE INSTRUCTION

The object of the instruction in this School is to impart knowledge of the fundamental principles of design, construction, and operation of structures and works of the civil engineering type, in addition to providing a liberal opportunity for study of general and cultural subjects. Emphasis is placed upon civil engineering as an applied science rather than as a vocational technique.

Civil Engineering students follow the first year with as thorough a preparation as possible in the following subjects: the survey, design, construction, and operation of buildings, roads, railroads, canals, sewers, and water works; the construction of foundations under water and on land, and of superstructures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbors, and lakes; the astronomical determination of geographical coordinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns, and irrigation and reclaiming of land; the applications and tests of hydraulic and electric motors; the preparation of drawings, plans, specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance, and jurisprudence. The latter subject deals principally with the fundamental principles of the law of contracts. Opportunity is also

given to seniors to specialize to a limited extent, or to broaden their training, by the election of certain courses, some of which may be chosen from approved courses in any department of the University. (For outlines of courses of study, see pages 60-71.)

The instruction in mathematics, chemistry, physics, geology, economics, psychology, and English is given in the College of Arts and Sciences. All other regular subjects are taught in the School of Civil Engineering, the School of Mechanical Engineering, or the School of Electrical Engineering.

Following is a brief outline of the scope and purposes of instruction in the various departments of the School of Civil Engineering:

Drawing and Descriptive Geometry. Engineering drawing is the graphic language of the industrial and professional world, and is used by engineers because of its exactness of expression. It is very important that the the engineering student understand the basic principles of this universal language as well as obtain facility in the art of drawing. The elementary courses offered give practice in the handling and use of instruments as well as training in accuracy, neatness, and speed. Descriptive geometry strengthens the power and habit of logical and exact thinking, and increases the ability to visualize in space. The advanced courses emphasize the use of theory in professional practice and provide knowledge and skill in making engineering drawings. The technical training acquired by the student engineer in these courses is important and necessary for his design courses, laboratory work, and later, his professional service.

Surveying. An important branch of civil engineering is the making of surveys for the accurate location of properties, for the purpose of mapping, and for the control of engineering works. Instruction is given in this department in the use of surveying instruments, in precise leveling and measuring, and in making topographic, hydrographic, subterranean, and geodetic surveys. The student is taught the elements of field astronomy, and makes astronomical observations in relation to survey control. Instruction is given in the principles and present practices in photographic and aerial surveying. An important feature of the instruction in this department is the work done by all students in the School at the Summer Survey Camp near Cayuta Lake, New York. Field practice is here given in topographic surveying, hydrographic surveying, and in precise leveling. Railroad and highway location surveying practice is also provided for the students. They become familiar with field organization, and hold the various positions in field and office parties.

Mechanics of Materials. In this department classroom and labora-

tory instruction is given to the student in the principles of mechanics as the fundamental basis for the design of engineering structures and works. An important feature of instruction in this department is the work done by the student in the laboratory, where he observes dynamical actions and the behavior of structural members under load. Demonstration and verification of the behaviors studied in the classroom are here developed. Opportunity is afforded the advanced student in mechanics for analytical and experimental work in the theory of elasticity, in photoelasticity, in the application of analogies, and in the use of models as they apply to engineering analysis and design.

Materials of Construction. The purpose of the work in the department is to acquaint the student with the processes of manufacture of the materials of construction, and the properties of these materials which are important in their behavior in engineering structures. In the laboratory the student is afforded opportunity to observe the actual behavior of materials under load and other service conditions. It is not the purpose of this instruction to develop laboratory technicians, but rather to provide the student with physical experience and concepts of the behavior of materials of engineering.

Hydraulics and Hydraulic Engineering. The work in this department begins with the fundamental behavior of fluids and continues into the design and operation of hydraulic works. In the Hydraulic Laboratory the student is instructed in the principles of hydraulic flow and measurement. The advanced student is afforded opportunity for study in hydrodynamics, experimental study in channel flow, pipe lines, weirs, spillways, and other hydraulic units. In waterpower engineering the student is given instruction in the methods of developing hydraulic power, the principles underlying the design and use of hydraulic machines, and in hydroelectric development. Instruction is given in the development and operation of public water supplies, reclamation, canalization, and river and harbor development.

Municipal and Sanitary Engineering. The object of the instruction in this department is to provide the student with the principles underlying sewer systems, the treatment of sewage, water supply and distribution, purification of water, operation of sanitary works, and trade wastes, and their treatments. Fundamental instruction in classroom and laboratory is given in sanitary biology and chemistry underlying the biological processes utilized in the purification of water and the treatment of sewage.

Transportation Engineering. The work in this department relates to the location, construction, operation, maintenance, and economics of

various agencies of transportation. Instruction begins in the economic location and construction of railways and highways, and continues with study covering maintenance-of-way and the operation and management of railroads and highways. A feature of the work in highway engineering is the laboratory instruction giving students experience in the study and testing of soils of highway subgrades, and in the testing of materials used in road construction.

Structural Engineering. In this department the student receives instruction in the design of bridges, buildings, and other structures of timber, masonry, concrete, steel, and other materials. Instruction is also offered in more advanced forms of bridge and building design and in the principles underlying their analysis. The student is also given instruction in the principles and methods involved in foundation work for bridges, buildings, and other land and waterfront structures. The new and growing field of soil mechanics is being developed as a part of the work of this department.

Regional and City Planning. Instruction in regional planning is given by the Colleges of Engineering and Architecture in cooperation. The work does not recognize regional or town planning as a separate profession, and hence no attempt is made to give the student technical proficiency in planning, nor even any large array of factual information. The courses deal in a broad way with the adaptation of man's environment to his needs and desires. A study is made of past and possible future achievement in the field of planned and controlled developments of public and private properties as the necessary basis for better living. Emphasis is placed on the fact that historically and logically the problems presented by large-scale planning are so difficult that no one professional group is competent to comprehend them, much less to solve them. It is shown that actual achievement must finally rest on the united efforts of groups composed of people of diverse interests and widely varying training. The courses offered are therefore open to upperclassmen and graduates in all colleges of the University.

Administrative Engineering. See page 38.

Research. Undergraduates who have shown the requisite proficiency and have available the necessary time may conduct special investigations under expert guidance. Such special work may consist of an analytical study or discussion of data, reports, and other engineering information already available, or it may be devoted to a design or construction or both of technical importance, or it may be an original investigation—analytical or experimental or both. In case the investi-

gation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. A limited number of seniors who have shown special ability for investigation may substitute research for some of the usual senior electives. See Course 297. Arrangements for research and thesis should be made with the Director of the School and the department concerned, preferably during the junior year.

EMPLOYMENT AFTER GRADUATION Civil Engineering graduates find employment in both technical and general business enterprises. In the technical field they are employed in surveying operations of all kinds, including land surveying, construction surveys, aerial surveys, and in the geological and geodetic surveys of the U. S. Government; in the design and construction of irrigation, reclamation, river and flood control, harbor improvement, and hydroelectric projects; in designing and constructing water supply systems, sewerage systems, filtration and purification plants; in the location, maintenance, construction, and operation of railroads; in all classes of highway work; in the design and construction of steel and reinforced concrete bridges and also of steel frame and reinforced concrete buildings; and in examining and testing the properties of materials. There is a growing field of service for the civil engineer in city and regional planning and in city management. Many civil engineers are also engaged in contracting. In the field of general business, experience clearly indicates increased opportunity in many business enterprises for the graduate in civil engineering because the training in analysis and precision are assets of value in the fields of finance, valuations, and real estate, and in other kindred activities of the business world.

Sibley School of Mechanical Engineering

EQUIPMENT The Sibley School of Mechanical Engineering, named in recognition of important gifts made by Hiram Sibley and his son, Hiram W. Sibley, occupies a group of buildings at the north end of the campus. In addition to the Sibley Buildings, this group includes Rand Hall, which was added through the generosity of Mrs. Florence O. R. Lang as a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr. The school is provided with a central working library in Sibley Dome and many of the departments also maintain special working and reference libraries.

Numerous laboratories and shops are available for carrying on the many activities of the School of Mechanical Engineering, as follows: the Materials Testing Laboratory, Heat Treatment Laboratory, and Metallography Laboratory, for determination of the physical properties of engineering materials under different kinds of stress and heat treatment; the Photoelasticity Laboratory, for instruction and research in photoelastic work; the Steam Laboratory, for instruction and research involving steam power; the Internal-Combustion Engine Laboratory, for work with this type of power equipment; the M.E. Hydraulics Laboratory, a pump-operated laboratory for hydraulic problems; the Lubrication Laboratory, for determination of the physical properties of lubricants; the Refrigeration Laboratory, for the study of refrigeration; the Fuel Testing Laboratory, for determination of the composition and calorific value of all types of fuel; the Foundry Sand Laboratory for determining the properties of various mixtures of sands and binders under the temperatures and pressures existing in foundry molds; the Micro-Motion Laboratory, for motion and time study; the Constant-Temperature Room, and the Heat Transfer, Heating, Ventilating, Air Conditioning Laboratories; a series of Research Laboratories; the Materials Processing Laboratories—formerly known as the Forge and Welding Shop, the Woodworking and Pattern Shop, the Foundry, and the Machine Shop; the Laboratory Boiler House; and the University Heating Plant and Power House.

OUTLINE OF THE INSTRUCTION

The object of the instruction in this School is to lay a broad and substantial foundation of general and technical knowledge and provide experience in engineering practice in the fields of mechanical engineering. Students of Mechanical Engineering are instructed primarily in the utilization of nature's sources of energy and materials for the benefit of mankind, through the development and application of prime movers, machinery, and processes of manufacture; thus, they have to do mainly with things dynamic. The province of the mechanical engineer includes the design, construction, operation, and testing of steam engines, steam turbines, boilers and power plant auxiliaries, gas and oil engines, hydraulic machines, pumping engines, railway equipment, compressed air machines, ice making and refrigerating machinery, equipment for heating and ventilating and air conditioning, machine tools, mill equipment, and transmission machinery. The work of the mechanical engineer further includes the planning of power plants

and factories, the selection and installation of their equipment, the development of systems of operation and manufacturing processes, and the organization and administration of plants and industries. In addition the mechanical engineer may engage in scientific research in the innumerable branches of this field.

Based upon the fundamental instruction of the freshman year, and that given in the sophomore year in advanced physics, mechanics of engineering, advanced applied mathematics, materials of construction, kinematics, drawing, materials processing, machine construction, and industrial organization and management, the junior student in mechanical engineering receives training in fluid mechanics (including hydraulics), machine design, economic organization, industrial accounting and cost finding, heat-power engineering, experimental engineering, and electrical engineering. In the senior year the student receives further training in the last three subjects and in heating, ventilating, and air conditioning, and also takes the courses outlined in one of the Senior Options. The respective Options provide for some degree of specialization in Steam-Power Plant Engineering, Heat Engineering (including fluid flow, heat transmission, refrigeration, and air conditioning), Industrial Engineering, Automotive Engineering, Aeronautical Engineering, Engineering Mechanics, Metallurgical Engineering, Mechanical Engineering Design, or in some other field allied to Mechanical Engineering; and, they also offer opportunity to elect various other courses of an advanced nature, such as those listed on page 116. The special work in these Options (A to I incl.) is described on pages 97–108. (For complete outlines of the four-year, five-year, and six-year courses in Mechanical Engineering see pages 97–114.)

The instruction in mathematics, chemistry, physics, and English is given in the College of Arts and Sciences. All other regular subjects are taught in the Sibley School of Mechanical Engineering, the School of Electrical Engineering, or the School of Civil Engineering.

The following is a brief outline of the scope and purposes of the instruction given in the various departments of the Sibley School of Mechanical Engineering:

(For *Administrative Engineering*, see page 36.)

Mechanics of Engineering. In this department, basic instruction is given in theoretical and applied mechanics, hydraulics, fluid mechanics, and applied mathematics, beginning with a course for sophomores in the fundamental principles of statics, kinetics, and strength of materials, in which an effort is made to teach students to think rather than to memorize. With this in view the free-body method is

used in the solution of problems involving forces, and students are required to work from fundamental definitions and principles rather than from formulas. The basic instruction in hydraulics and fluid mechanics is supplemented by laboratory practice given in these subjects in the Department of Experimental Engineering.

Advanced courses for seniors and graduates are offered in applied elasticity, photo-elasticity, the theory of elastic stability, the mechanics of vibration, and fluid motion important in hydraulics and aeronautics. These courses are intended to introduce the student to modern ideas in development, testing, and investigation involving solid and fluid mechanics. For those who desire to specialize in this field a special option in Engineering Mechanics is offered. See page 105.

Machine Design. In this department instruction is given in kinematics and machine design to sophomores and juniors in mechanical, electrical, and administrative engineering, and in machine design to seniors in chemical engineering. The department also offers elective courses open to sophomores, juniors, seniors, and graduates. Instruction is given by means of recitations and work over the drawing board. Kinematics is studied and applied to the solution of cam, gear, linkage, instant center, velocity, and acceleration problems. The courses in kinematics are followed by recitation and drawing-room instruction in general machine design. The theory and principles developed in the class room are applied to the solution of many short problems and in the drawing room to the solution of longer problems for which computations and drawings are made. Only such problems as lend themselves to rational analysis to the greatest degree are selected. The calculations are regarded as an important part of the work and the student's design is criticized from the standpoints of appearance, cost, convenience, economy of shop operations, lubrication, accessibility, ease of assembly, economy of upkeep, etc. The Department offers also a senior option in Mechanical Engineering Design.

Heat-Power Engineering. Instruction in this department is given to all juniors and seniors in mechanical engineering, juniors in electrical and administrative engineering, and seniors in civil engineering, with the object of training them to solve problems involving the theory, design, performance, selection, and economics of steam, internal-combustion and other heat engines, refrigerating machines, gas compressors, and related auxiliary equipment, considered both separately and in combination in power plants. This instruction in fundamentals begins with the elements of heat-power engineering, including the study of the thermodynamic properties and processes of gases, vapors,

and mixtures; ideal and actual gas and vapor cycles; air compressors; internal combusion engines; and steam engines. This is followed by a study of steam turbines, fuels, combustion, heat transmission, flow of gases and vapors, furnaces, steam-generating units, draft apparatus, condensers and other heat exchangers, refrigeration, the utilization of waste heat, and other related topics. Two Senior Options are offered by this department—one, Option A, in Steam and Oil-Engine Power Plants, and the other, Option B, in Fluid Flow, Heat Transmission, Refrigeration, and Air Conditioning. In addition, the department gives a course on heating, ventilating, and air conditioning, which is required of seniors in mechanical engineering, except those in Option B, and is elective for others. Elective courses are also offered on steam turbines, power plant economics, steam generating equipment, internal combustion engines, refrigeration, graphical computations, advanced thermodynamics, advanced heat-power engineering, and research.

Mechanical Experimental Engineering. Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses. Throughout the junior and senior years the student receives instruction in the completely equipped mechanical laboratories not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but also to teach him the best methods of research. Briefly, the courses include the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, and other instruments; tests of lubricants; fuel calorimetry; steam calorimetry; tests of boilers, steam engines, turbines, pumps, heaters, condensers, injectors, and other steam apparatus; tests of heat transfer; tests of fans, air compressors, and refrigerating machines; tests of internal combustion gas and oil engines; and tests of hydraulic machinery. The department also offers elective courses in applied metallography and in mechanical engineering research.

Industrial Engineering. All seniors in administrative engineering and those in mechanical engineering who elect the Industrial Option C receive in this department instruction in the principles and current problems of Industrial Engineering. The principles governing manufacturing methods, along with selection and arrangement of equipment, are studied and a layout made for a modern manufacturing plant. Methods of production and material control are studied as well as organization and engineering economy. The subject of motion and time study is presented, including micro-motion and the principles

of motion economy. The department conducts a micro-motion laboratory equipped with the necessary apparatus for taking and analyzing motion pictures. The purpose of the Industrial Engineering Option is to prepare the student for his future work by a thorough grounding in the fundamentals supplemented with as many practical applications as possible.

Automotive Engineering. Since automotive engineering is merely a branch of the general field of mechanical engineering and is dependent on the basic preparation covered in the first three years of the regular curriculum, the special instruction of the Automotive Option is deferred until the senior year. This special work covers the wide variety of theoretical and practical problems in design and operation which are of great importance in the industry; applies the fundamental principles that have been studied in the previous years; reviews the topics that are usually covered by books on the subject; and makes a special study of current developments. The instruction is given by means of lectures and computing courses. The lectures may be elected by seniors in other options. Provision is made also for conducting experimental investigations in this field.

Aeronautical Engineering. Since aeronautical engineering is a highly specialized field with limited opportunities for employment in advanced design and research, and with requirements that cannot be met in a four-year course without eliminating some of the broad foundation courses essential in all branches of mechanical engineering, this School centers attention on only the more basic and elementary courses in this field, the instruction being given mainly in the senior year. (See Option E, page 104). Most of the opportunities in the aeronautical industry do not require the highly specialized training; instead the principal need is for men versed in broad engineering fundamentals. Students qualified to pursue the special study further are encouraged to take graduate work.

Metallurgical Engineering. As the iron and steel and other metal producing or fabricating industries employ a larger percentage of graduates in mechanical engineering than other industries do, a metallurgical option is offered for students interested in this field of engineering. The courses in the option give a broad foundation of theory and practice in metallurgy as applied to mechanical engineering and constitute a sound basis for further specialization at the graduate level if the student elects to pursue this type of work. Special studies begin in the third year with a course in Introductory Metallography. This is followed in the senior year by courses in

Applied Metallography, Advanced Metallography, and Research in Metallurgy.

Materials Processing. In this department instruction is given in the various processes used in shaping or forming materials, with the object of emphasizing the fundamentals of each basic operation in such a way that the student can analyze and understand the more complex processes and highly specialized equipment that are constantly being developed. The knowledge thus acquired leads to an understanding of production processes as they are related to the design, development, and cost of manufacture of structural parts. The discussions of each method or process are supplemented by practice in the use of the related machines and equipment.

In the freshman year hot-working and metal-joining processes are covered in one course, and casting processes and pattern making in another. In the former the principles of rolling, extrusion, drawing, and forging processes are covered; and under metal-joining processes stress is given to modern practice in oxy-acetylene and electric welding. Instruction in the casting processes includes a general survey of the various types of castings and the methods used in their production, and this is accompanied by demonstrations and discussions of the more specific phases of each. Instruction in pattern design and construction is given in close connection with that in foundry practice.

In the sophomore year emphasis is given to machine tool processes, including grinding, but other important cold forming operations are covered also. The underlying principles of removing metal in the form of chips are studied with attention to modern cutting tool materials and the economy of production. Machine tools are considered from the standpoint of basic operations and of their applications to specialized equipment. A study is made also of measuring instruments, jigs and fixtures, and inspection methods.

Cold forming methods—such as cold rolling, drawing, and spinning—and their applications are discussed and demonstrated. Punch and die work is also illustrated. Students are encouraged to conduct advanced research in the various branches of materials processing.

Engineering Research. Undergraduates who have shown the requisite proficiency and have available the necessary time may aid in the investigations conducted by the Engineering Experiment Station (see page 15) or conduct special investigations of their own under expert guidance. Such special work may consist of an analytical study or discussion of data, reports, and other engineering information already available, or it may be devoted to a design or construction or both of

technical importance, or it may be an original investigation—analytical or experimental or both. When occasion offers, qualified students may assist in commercial tests, made at the University or elsewhere, of materials, prime movers, machines, power plants, air conditioning equipment, etc. In case the investigation or research is sufficiently extensive, the student is encouraged to embody the work in a Thesis.

A limited number of seniors who have shown special ability for investigation may substitute Research (or Thesis) for some of the usual senior electives or for courses in an option.

Arrangements for Research or Thesis should be made with the Director of the School and the department concerned, preferably during the junior year.

EMPLOYMENT AFTER GRADUATION

Mechanical Engineering applies to nearly all branches of the industries; hence, it is called upon for the design, construction, operation, and testing of prime movers and other machinery, and of complete plants of many kinds, not only in its own immediate province but in the various other fields of engineering. Mechanical engineers serve also as planners of new projects and processes, and as power plant engineers, industrial engineers, fuel and combustion engineers, automotive engineers, aeronautical engineers, refrigeration engineers, air-conditioning engineers, and water-power engineers—to mention but a few of the many special fields open to them. Their training often serves also as an important foundation for employment in various branches of business connected directly or indirectly with engineering. Thus, the opportunities for employment after graduation are quite extensive.

School of Electrical Engineering

EQUIPMENT

The School of Electrical Engineering is housed in Franklin Hall, in a portion of Rand Hall, in the High Voltage Research Laboratory, and at the Broadcasting Station and Studios. The School's library is the Alexander Gray Memorial Library, so called because it originated in a generous gift of the McGraw-Hill Book Company in memory of Professor Gray, the first Director of the School. The library is a unit of the combined Mechanical and Electrical Engineering Library and is housed in the Sibley Dome. Laboratories and demonstration facilities of the School include the Lecture Room, with provision for experimental demonstrations to accompany the earlier lectures in electrical principles

and applications; the Electrical Machinery Laboratories, with a great variety of both direct and alternating-current machines; the Electronic Laboratory, equipped for a wide variety of tests of electronic devices; the Standardizing Laboratory, for checking of secondary standards and meters; the Electrical Communication Laboratory, well provided with apparatus to illustrate modern electrical communication; and the Broadcasting Station and Studios, from which numerous University programs are broadcast, and which are available for instruction and research. The new High Voltage Research Laboratory provides excellent facilities for demonstration, tests, and research on all types of insulation and on high voltage lines, switchgear, transformers, and other apparatus.

OUTLINE OF THE INSTRUCTION

The four-year course in electrical engineering provides a strong fundamental training in the analytical study of scientific subjects common to all branches of professional engineering. On this foundation is built a coordinated program of basic work in the several branches of general engineering technology, economics, and administration, together with a major study of electrical engineering principles and their application in various fields. The study of electrical engineering proper is begun in the sophomore year, as soon as the student is sufficiently advanced in the fundamental sciences, and it gradually becomes the major study. In the last three years of the course the student receives a thorough training in electrical engineering, in addition to training in applied mechanics, machine design, thermodynamics and heat power, and mechanical laboratory. The instruction in electrical engineering is of a distinctly scientific character and requires analytical ability of a high type. Courses are given in the theory of electricity and magnetism, electrical machinery, electronic devices, rectifiers, electrical circuit analysis, mathematical applications, and the theory and practice of electrical engineering. Laboratory work serves to amplify, and is given in parallel with, the theory. Opportunity is offered seniors to specialize to a limited extent in such subjects as application of electricity to industrial problems; electric power generation, transmission, and distribution; electric lighting; communication engineering; and research. Opportunity is also offered to qualified students who have a special liking for physics, chemistry, or mathematics to specialize in those subjects. (For courses of study see page 136.)

The student in electrical engineering also takes a large proportion

of the work given to mechanical engineering students, so that he is not limited in outlook or choice of work after graduation. For those who desire a still more comprehensive study of mechanical engineering, a combined five-year program is offered, leading to both the B.E.E. and B.M.E. degrees. (See page 142.)

For those desiring a broader training in general fields, including more of the liberal arts, a five-year course of study leading to the B.E.E. degree may be arranged, which includes the equivalent of an additional year of liberal arts work. A six-year program is also offered, leading to the A.B. degree at the end of the first four years, and the B.E.E. degree at the end of the sixth year. (See page 144.)

The instruction in mathematics, physics, chemistry, and English is given in the College of Arts and Sciences. All other subjects in the regular curriculum are given in the various departments of the Sibley School of Mechanical Engineering, the School of Civil Engineering, and the School of Electrical Engineering.

Following is a brief outline of the scope and purpose of instruction in the various courses of the School of Electrical Engineering:

Fundamentals of Electrical Engineering. In the early work in electrical engineering the physical phenomena are demonstrated in the lecture room, and their mathematical analysis discussed. Study of lecture material and text is assigned for home work and simple problems are solved. More difficult problems are solved in the computing room under the supervision of an instructor, and the difficulties most generally encountered are clarified in recitation periods. Thus, special care is given to be sure the student has a firm grasp of basic principles and their applications, so that in the more advanced work he can think clearly for himself, with less supervision on the part of the instructor.

All electrical engineering students are given a basic course in electronics during the second term of the junior year which prepares not only for later specialization in radio and communication, but also for the ever-increasing application of electronics in other fields.

The work given to civil, mechanical, and chemical engineers is no less fundamental than that given to electrical engineering students, but is necessarily less extensive and is selected and presented in sympathy with their probable needs and point of view.

Engineering Mathematics. As electrical engineering requires a high order of mathematical ability, the regular courses in mathematics are supplemented by courses adapted primarily for the electrical engineer. Stress is laid upon the solution of equations, determinants, Fourier and other series, and elementary differential equations.

Advanced Electrical Engineering Theory and Practice. In the senior year students are given training in more advanced subjects and in the application of the basic principles to give a thorough understanding of electrical apparatus and machinery.

The theoretical work covers the application of such mathematical tools as determinants, Fourier's series, symmetrical components, and dimensional analysis to engineering problems. Stress is laid upon the solution of problems of electrical and magnetic circuits, in both steady and transient states.

The principles studied in the theoretical work are applied, in the course in practice, to the detailed study of electrical apparatus and machinery, and to many of the important problems of the practicing engineer.

Experimental Electrical Engineering. Throughout the last two years the student receives instruction in the electrical laboratories which closely parallels and is coordinated with the theoretical instruction. The purpose of laboratory work is to develop in the student a scientific attitude, as well as to teach him the characteristics of the equipment and the methods of testing. The work is planned to afford constant original application of principles previously covered in theory courses.

Electric Power and Design. During the senior year the student may elect an Option in Electric Power and Design. Under this option he selects several courses which prepare primarily for later work in the power field, either with manufacturing concerns or with public utilities. Work offered under this option includes courses in the design of electrical apparatus, the transmission and distribution of electric power, the principles of electrical power plants, and economics of public utilities.

Electrical Communication Engineering. A student electing the Electrical Communication Option chooses a group of courses in this field which will prepare him primarily for later work in radio, telephony, telegraphy, and related fields. The basic course runs throughout the year and provides a thorough study of communication apparatus and circuits, with particular emphasis on the application of thermionic tubes to the art. Later work treats transmission theory over wires and through the ether, radiation systems, and associated circuits. In auxiliary courses the student may specialize in a study of communication networks. Students selecting either the Communication or Power Option may elect a course in the rapidly expanding field of ultra-high frequency radio waves which is of great importance to the nation's war effort.

Illumination. Electrical illumination has made rapid strides in recent years, and offers promising fields for the engineer. Courses in the engineering principles of illumination are regularly offered and special work may be arranged.

Elective Courses. Elective courses in particular fields are regularly given for qualified students who are particularly interested. Included among these are courses in Heaviside's operational circuit analysis, in industrial applications and control, and in the engineering aspects of patents.

Electrical Engineering Research. Students who have shown the requisite proficiency may conduct special investigations under expert guidance. Such work may consist of an analytic study and discussion of data, reports, and other engineering information already available, or it may be devoted to a design or construction, or both, of technical importance, or it may be an original investigation of either an analytical or experimental nature. Students who have shown proficiency in the conduct of research may be permitted (with the approval of the faculty) to substitute research for some of the senior elective and option courses.

EMPLOYMENT AFTER GRADUATION

Graduates in Electrical Engineering find employment in many fields. In the electric power field it may be with manufacturing companies in connection with the design, construction, testing, and application of electrical equipment, or with public utilities in connection with the generation, transmission, distribution, and sale of electrical energy. They are also employed to determine the costs involved in the utilization of electricity and to investigate the rates charged for this service.

With the continued increase in use of electricity in industry, electrical engineers are needed in all industrial plants to select and install new equipment for motor drives, electric heating processes, electric welding, transportation, electro-chemical and electro-metallurgical processes, etc.

In the communication field many graduates are employed in the design and manufacture of radio receiving sets and broadcasting equipment, and in the design and operation of broadcasting stations, as well as in the telephone and telegraph industries.

Men gifted with originality and scientific imagination find opportunities for employment in research and in the development of new applications for electric power.

The analytical and practical training provided in the course in electrical engineering is of great value in the field of general business, and many graduates are so employed.

School of Chemical Engineering

EQUIPMENT The specialized training in Chemical Engineering is given in Olin Hall of Chemical Engineering. The courses in chemistry are given in Baker Laboratory of Chemistry. An unusually complete library of chemistry and chemical engineering is available. Laboratories for metallography, chemical microscopy, and other special fields of chemical engineering and chemistry provide unusual facilities for instruction and research in these special fields.

Olin Hall of Chemical Engineering, which is provided through the generosity of Franklin W. Olin as a memorial to his son Franklin W. Olin, jr., will be ready for occupancy by October 1942. This modern and well-equipped building, with about 105,000 square feet of available floor space, will provide lecture-room, recitation-room, and laboratory facilities for all of the instruction in chemical engineering. The unit operations laboratory, which is about one hundred feet long and fifty feet wide, extends through three floors, and will house semi-plant scale equipment for both instruction and research. It is served by a traveling crane, and by its own shops and analytical laboratory. A considerable part of the building is subdivided into unit laboratories for advanced and graduate students.

OUTLINE OF THE INSTRUCTION The purpose of the instruction in this School is to provide a broad foundation of training in the fundamental subjects of mathematics, chemistry, and physics, and in the essential principles and methods of engineering, and professional training in the specific field of chemical engineering. In the required curriculum a certain amount of work in cultural subjects is included. By providing elective work in the later years, the curriculum makes it possible for the student to take additional courses either in subjects outside the field of his major interest or in special and advanced technical subjects within that field.

Students receive during the first two years a thorough training in the fundamental subjects upon which their specific professional work is based: mathematics, physics, introductory, analytical, and organic chemistry, English, and German. The third and fourth years include

more strictly technical and more advanced courses in engineering and in chemistry, and the fundamental courses in the specific field of chemical engineering. The fifth year includes the more advanced work in engineering and in the specialized field. (For an outline of the course of study see page 153.)

EMPLOYMENT AFTER GRADUATION Graduates in Chemical Engineering find employment in the design, development, operation, and administration of chemical engineering plants. There is also some demand for men with chemical engineering training for technical sales work in connection with the selling of chemical products and chemical engineering equipment. A relatively large number of the graduates in chemical engineering continue their specialized training as graduate students in chemical engineering or in chemistry and eventually receive industrial positions as research chemists or research chemical engineers.

Administrative Engineering

PURPOSE OF THE INSTRUCTION The large number of engineering graduates who hold administrative positions is evidence of the usefulness of special training for these positions. Engineering methods are finding increased application in problems of executive management. This is due in part to the increasing scientific development underlying the operation of works and processes, and in part to the nature of the training of the engineer in fact-gathering and analytical study.

Students of administrative engineering in the Schools of Civil, Mechanical, and Electrical Engineering receive substantially the same basic training in mathematics, physics, chemistry, geology, economics, mechanics, surveying, shopwork, materials, etc., as do the other engineering students in these schools. In the more specialized technological subjects covered in the latter part of the regular courses in civil, mechanical, or electrical engineering the work is shortened by not quite one half to provide place for a coordinated group of courses in Business Organization and Management, Accounting, Money and Banking, Statistical Theory and Practice, Marketing, and Business Law, together with English, Technical Writing, and Public Speaking. The aim of these courses is not only to preserve the basic content and spirit of the engineering training but also to in-

corporate with it training in the fundamentals of industrial management. Students in the School of Chemical Engineering have opportunity to elect many of the courses in Administrative Engineering while pursuing the normal curriculum of that School.

IN MECHANICAL ENGINEERING

In the special curriculum in Administrative Engineering for mechanical engineers, the freshman year is the same as that given to other engineering students. During the next three years all students in the program are required to take a balanced group of technical and economic courses. About 68 per cent of the course content of the curriculum is devoted to regular engineering subjects in order to give a substantial groundwork in fundamental engineering, a prime requisite for the principles of scientific management. The remaining 32 per cent of the curriculum is made up of business and economics subjects especially designed to fit the needs of modern industry.

It is recognized that the four functions of business and industry are marketing, production, finance, and accounting. Starting with a basic course in Business and Industrial Management in the sophomore year, the Department of Administrative Engineering in the School of Mechanical Engineering accordingly has built for this curriculum a series of carefully coordinated courses in Technical Writing, Accounting, Cost Finding, Cost Control, Corporation Finance, Industrial Relations, Statistics, Engineering Business Law, Industrial Engineering, Production Management, Marketing, Business and Industrial Problems, and Personnel Management in Industry. Supplementing these are courses in English and Public Speaking. To supply close contact with the outside world, a series of special lectures is given by business leaders who appear weekly before the senior classes.

For the outline of the four-year curriculum, see page 109, and for a five-year course leading to the degrees of B.M.E. and B.S. in A.E., see page 113.

IN ELECTRICAL ENGINEERING

The course differs from that offered in mechanical engineering in that more stress is given to fundamental electrical engineering with special reference to the applications of electrical power and to public utility engineering. See page 140.

The requirements for admission are the same as for the regular four-year B.E.E. course. See page 40.

It is possible by an additional year of study to receive the degree of Bachelor of Electrical Engineering, provided the student signifies this intention at the beginning of the sophomore year. (See page 141.)

IN CIVIL ENGINEERING

In order to strengthen the instruction in the economic, financial, legal, and functional aspects of business without at the same time sacrificing the fundamental instruction of civil engineering in its various branches, the School of Civil Engineering offers an Administrative Option leading to the degree of B.C.E., and a four-year course in Administrative Engineering leading to the degree of B.S. in Administrative Engineering (B.S. in A.E.). Students working for the regular B.C.E. degree also take some of the administrative courses, such as Engineering Law 290 and Engineering Management 293. See pages 63 and 69.

IN CHEMICAL ENGINEERING

In the School of Chemical Engineering, no separate degree in Administrative Engineering in Chemical Engineering is offered. The normal curriculum leading to the degree of Bachelor of Chemical Engineering provides a total of 19 hours of elective work in the fourth and fifth years. By selecting his elective courses in the field of Administrative Engineering, a student registered for the degree of Bachelor of Chemical Engineering can arrange an option in this field and can obtain instruction in financial, legal, and economic subjects to prepare him for administrative work in Chemical Engineering.

EMPLOYMENT AFTER GRADUATION

Upon graduation, students, who take administrative engineering, whether in civil, mechanical, or electrical engineering, are not unqualified to accept the same types of engineering positions open to other engineering graduates. Having the basic training in the fundamentals of engineering, administrative engineering graduates can, and many do, accept positions in the more technical phases of engineering. However, the election of the student to take administrative engineering indicates a leaning toward engineering problems related to business management.

The opportunities in the field of administration for one trained as a civil engineer have been increasing with special rapidity in recent years. Railroad and public utility operation and management, high-

way administration, the broad field of construction, the operation and maintenance of public works, transit systems, river and harbor facilities, power developments, reclamation and conservation works, city and regional planning, and city management offer large and rapidly growing fields of administrative service for the civil engineer.

In mechanical engineering, the rapid increase in the size of the industrial concerns has created many positions for the administrative engineer between the top management and the man in the shop—positions in production engineering; in cost estimating, inventory control, and quality control; in factory planning and maintenance; in accounting and finance; or in statistical and economic studies. Furthermore, the growing importance of the selling phase of business has created a demand for the engineer trained in the principles of industrial marketing. This is a field for which administrative engineers are particularly well qualified and in which approximately 25 per cent sooner or later find employment.

In the electrical field there are many positions which require a basic understanding of electrical engineering and an understanding of human relationships. Such fields are technical sales work for electrical manufacturers, either as the employee of a large corporation or as the independent representative of smaller manufacturers; commercial work for public utilities, as in the promotion of the use of electricity for lighting, for industrial heating, or for special industrial processes; production control, cost analysis, factory management, and many other phases of manufacturing. The rapid advancement of many men in these fields in recent years indicates that opportunities are available for men who have the basic engineering training supplemented by business training and studies of economic principles.

Admission to the College

THE METHOD OF APPLICATION

All correspondence concerning admission to the College of Engineering should be addressed to the Director of Admissions, Cornell University, Ithaca, N. Y., who will forward the necessary blank form of application on request. All credentials relating to the admission of a student in September should be sent to the Director of Admissions before August 1.

An applicant for admission must not only satisfy the entrance requirements of the College of Engineering, which are printed on page 41, but must also comply with the University's rules governing admission. These rules require, of every applicant for admission to an undergraduate course of study, (1) a certificate of good character, (2) a deposit of $25, and (3) a certificate of vaccination against smallpox. These rules are fully and clearly stated in the University's *General Information Number*, which every candidate for admission should read carefully and which can be obtained by application to the Secretary of the University.

FOUR WAYS OF ENTRANCE

There are four ways of satisfying the entrance requirements. They are fully described in the University's *General Information Number*, which every candidate for admission is advised to consult. In brief they are as follows:

1. By passing the June examinations of the College Entrance Examination Board in the required subjects.

2. By passing the necessary Regents examinations. This option is for students who have prepared in New York State.

3. By presenting an acceptable school certificate.

4. By passing certain of the September examinations of the College Entrance Examination Board.

SELECTIVE ADMISSION

The number of applicants admitted to the several schools of the College of Engineering is limited by the facilities available for adequate instruction. Since the number of applicants exceeds these limits the Committee on Admissions in each of the Schools will exercise discretionary power in selecting those to be admitted. Preference will be given to those candidates

whose academic preparation and personal character indicate fitness to pursue with success the course of study to be undertaken, who show evidence of professional promise, and who complete the filing of their entrance credentials in ample time for the Admission Committee to give thorough consideration to their qualifications.

ADMISSION AS A FRESHMAN

For admission to the freshman class in a four-year or five-year course in engineering an applicant must be at least sixteen years of age and must offer fifteen specific units of entrance subjects, as follows:

English (four years)		3 units
Mathematics:		
Elementary Algebra	1 unit	
Intermediate Algebra	1 "	
Plane Geometry	1 "	
Advanced Algebra or Solid Geometry	½ "	
Plane Trigonometry	½ "	
Total, Mathematics		4 units
History, 2 units, or One Foreign Language*, 2 units		2 units
(German, French, Spanish, Italian, Greek, or Latin)		
Physics or Chemistry**		1 unit
Electives		5 units
Total		15 units

With respect to the specific list of entrance subjects the following paragraphs should be noted:

1. *Mathematics.* The four units of Mathematics required may be offered under the specific subjects and units above listed, or they may be offered as four years of continuous training in Mathematics throughout the high or preparatory school course, provided that in the latter case a declaration is attached to the certificate of credits stating that the course in Mathematics has included the essentials of the four units of Mathematics as required by the Gamma Examination of the College Entrance Examination Board.

*Students who expect to enter the Graduate School after obtaining a first degree should note that although there are no foreign language requirements for the masters' degrees in Engineering, proficiency in two, preferably German and French, is required for the doctorate.

**Candidates for admission to the School of Chemical Engineering *must* offer one unit of Chemistry, and should offer also one unit of Physics.

2. *Elective Units.* The five elective units may, with one exception, be made up of any of the entrance subjects and units acceptable to Cornell University. For a list of those subjects and units, see the *General Information Number* (Table 1, on page 7.) The one exception is that credit for a single unit in a foreign language will not be granted unless the candidate offers three units in another foreign language or two units in each of two other foreign languages.

3. *Special Consideration of Units.* Applicants offering fifteen units which do not differ materially from the specific list may present their credits for special consideration, for under proper circumstances some adjustment may be permitted. If there is a deficiency of one-half unit in Advanced Algebra or Solid Geometry, the applicant may be admitted, taking the shortage as extra work during the first term, provided his scholastic standing is sufficiently high to indicate that this program can be carried successfully. This adjustment requires the special approval of the School which the student desires to enter. However, the student is strongly urged to be free of entrance shortages at the time he enters. Attention is called to the possibility of obtaining additional credits by attending the Summer Session (see the *Announcement of the Summer Session*) or by taking the September examinations.

4. *French or German Recommended.* It is recommended that if foreign language units are offered they be in French or German, for the reason that a knowledge of either of these tongues gives the student immediate access to important literature on the theory and practice of engineering. For the purpose of entrance requirements, the substitution, unit for unit, of scientific French or German is permitted, in lieu of a more general literary course in either of those subjects, and this substitution will apply to all such courses in any secondary schools approved by the Director of Admissions.

5. *Language and History.* The student preparing to enter the College of Engineering is strongly advised to offer at least three of his elective units in Language and History. His work in the four-year course in engineering will of necessity be largely scientific or technical. He will therefore do well in his preparatory years to avoid unnecessary specialization and to make his studies as liberal as possible. Applicants who have not had this broader education are recommended to take either a five-year course or a six-year course. See page 10.

6. *Practical Experience.* Students who have had some practical experience in engineering usually gain more than others from the courses offered by the College of Engineering. It is therefore recom-

mended that prospective students spend at least one summer vacation in practical work in connection with some kind of engineering.

SIX-YEAR COURSES The requirements for entrance to one of the six-year courses, leading to the degree of Bachelor of Arts and one of the bachelor's degrees in Engineering (B.C.E., B.M.E., B.E.E., or B.S. in A.E.), are those of the College of Arts and Sciences, where the candidate for the two degrees is registered during the first four years. They include less mathematical preparation than is specified for the four-year or five-year courses. The necessary arrangement of studies in the six-year course is set forth on page 10.

ADMISSION FROM ANOTHER COLLEGE A student who has attended another college may be admitted to advanced standing, provided he is in good standing and has made a satisfactory scholastic record in the college from which he comes and provided also that he meets the full entrance requirements of the College of Engineering. An applicant for admission in this way should file by mail with the Director of Admissions of Cornell University, on an official blank to be obtained from him, a formal application for admission stating definitely the branch of engineering desired, and should include (1) an official certificate, from the college or university already attended, of his honorable dismissal, his entrance credits in detail, his terms of attendance and the amount of work that he has completed, (2) a detailed statement of the courses pursued, and (3) the drawings and reports for which credit is desired. He should also send a catalogue of the institution attended, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

SPECIAL STUDENTS Applicants who do not wish to become candidates for any of the undergraduate degrees may, in exceptional cases, be admitted to the College of Engineering as special students. Such students may be of two classes:

1. Those students who can not meet the entrance requirements or do not wish to spend the required time to complete the course. Special students of this kind must be at least 21 years of age, must have had some engineering training, and must have the prerequisites for the courses they wish to take.

2. Those students who, having a baccalaureate degree, wish to pursue further work at the undergraduate level. Such students must have the prerequisites for the courses they wish to pursue.

It is further provided that all special students must register for a minimum of 15 credit-hours of work each term, and pay the same tuition and fees required of other undergraduate students. Special students may not receive a degree except upon the completion of both the entrance requirements and the undergraduate work specified for that degree.

Payment to the University

TUITION FEE For instruction in the College of Engineering during the regular session the University charges a tuition fee at the rate of two hundred dollars a term. For all the rules concerning the payment of the tuition fees see the *General Information Number.*

OTHER FEES For certain services or privileges which the student enjoys the University charges fees over and above that charged for tuition. (See the *General Information Number.*) Every undergraduate student of the College of Engineering is required to pay fees as follows:

A Matriculation and Examination Book Fee of $11 is required of every student upon entrance to the University. This fee must be paid at the time of registration. A new undergraduate student who has made the required deposit of $25 with the Treasurer does not make an additional payment of this fee, because the Treasurer draws on the deposit for it.

A Health and Infirmary Fee of $7.50 a term is required at the beginning of each term.

A Willard Straight Hall Membership Fee of $5 a term is required at the beginning of each term.

A Physical Recreation Fee of $4 a term is required at the beginning of each term.

A Laboratory Fee is required to be paid at the beginning of each term at the following rates: freshmen in the School of Civil Engineering, $12.50; all students in Mechanical Engineering and Electrical Engineering, $12.50, but not for more than eight terms; students in the last three years of the course in Chemical Engineering, $12.50; sophomores, juniors, and seniors in Civil Engineering, $4. The term fees in courses in freshman and sophomore Physics are $5 and $2.50 respectively. Fees are also charged for Engineering Geology ($4.50), Public Speaking ($2), and some of the elective courses.

The Shop Instruction Fee for non-engineering students is $3.50 a credit hour.

Automobile Registration and Parking. See Automobile Regulations in the *General Information Number.*

REFUND OF TUITION TO DRAFTED STUDENTS

Students who volunteer or are drafted for service to the National Government at such a time that they can not receive any academic credit for the term in which they leave for such service will be entitled, under an act of the Board of Trustees, to a refund in full of the tuition paid for that term. If some academic credits are granted and some are not, tuition paid for the term will be refunded in an amount proportional to the credits not granted.

DEPOSITS

Laboratory Deposits. In some courses, particularly in Chemistry, the student is required to make in advance at the Treasurer's office a deposit of money to cover the cost of material to be used and supplies to be consumed by him in the course of the term. Accounts are kept and charges are entered against the deposit. At the end of the term any balance remaining of the deposit is returned to the student. Freshmen in the Schools of Civil, Electrical, and Mechanical Engineering, including those taking Administrative Engineering, deposit $11 a term for first-year Chemistry. Students in Chemical Engineering make additional deposits.

R.O.T.C. Uniform Deposit of $20. Every student enrolled for the Basic Course of Instruction in Military Science and Tactics is required to deposit $20 at the Treasurer's office for the purchase of his military uniform. An immediate deposit is required because enrollment in the Department of Military Science and Tactics takes place at once. Most of the amount of the student's deposit is returned to him as earned uniform allowance upon his completion of the two-year Basic Course.

LIVING COSTS

The average student's allowance for the necessary expenses of the normal two-term freshman year at Ithaca, over and above the amount of the tuition fee, ought to be at least $800. That is the sum of $550 for room and board; $150 for fees, including laboratory fees and deposits, books, instruments, stationery, and other supplies; $50 for laundry, and $50 for miscellaneous personal expenses. This subject is discussed at length in the *General Information Number.*

Means of Financial Aid

AID FOR NEW STUDENTS

Cornell University's provision of financial help for new students of the College of Engineering consists of certain scholarships which are awarded on the basis of competition, many of them to students entering the freshman class. Prospective freshmen are eligible to compete for twenty-five University Undergraduate Scholarships, 150 State Cornell Scholarships for residents of the State of New York, and a few others, most of which are restricted to residents of certain localities. The John McMullen Regional Scholarships in Engineering are available for new students coming from outside New York State.

John McMullen Regional Scholarships are awarded annually to thirty or more selected students entering the College of Engineering. Entering male students whose preparatory work was completed at a school outside New York State and those students from New York schools who are ineligible, at the time they enter, for the Cornell Tuition Scholarships and the State Cash Scholarships offered by the State of New York are eligible to compete. These scholarships have variable stipends up to $400 a year and may be held throughout an undergraduate course of study, provided the recipient maintains the required academic record. They were established by the Board of Trustees from a portion of the income of a munificent gift to the University by the late John McMullen of Norwalk, Connecticut, and are alloted among fifteen districts of the United States. A student is not eligible for both the State and McMullen Regional Scholarships at the same time. Application blanks and instructions are sent, about January 1 of each year, to the principals and headmasters of accredited schools for their use in recommending outstanding candidates who wish to enter the College of Engineering. An application blank will also be sent direct to the candidate upon request to the Committee on Scholarships, College of Engineering. The applications are to be returned to the Chairman, Committee on Scholarships, before March 1. The candidates selected by the Committee for final consideration are requested to take the Scholastic Aptitude Test of the College Entrance Examination Board in April. These candidates are also interviewed by members of an alumni scholarship committee in their respective districts. Final selections are made by the Committee on Scholarships, and the Dean, based upon the secondary school record,

the aptitude test, and the qualities of character and general ability, as determined by the personal interview. The successful candidates are appointed by the President of the University.

The John McMullen Industrial Scholarships in Engineering are awarded each year to four graduates of secondary schools who have spent some time in industry and have had apprentice training, preferably in a formal course given by an industrial concern. Candidates must be sponsored by responsible officers of the companies by which they have been employed. Each scholarship has a value of $400 a year, and may be held throughout an undergraduate course of study provided the recipient maintains the required academic record. Inquiries should be addressed to the Chairman, Committee on Scholarships, College of Engineering, preferably not later than February, so that formal applications may be filed with the Committee on Scholarships before April 1.

For particulars of all other scholarships that are open to new students, the *General Information Number* should be consulted.

GRANTS AND OTHER AID

Students who establish superior academic records become eligible for John McMullen Regional Scholarships after one term of residence, regardless of the state in which they reside. Other scholarships, grants, and loans open to undergraduates are reserved for students who have been in residence and good standing at Cornell University for at least a year.

Any student in the College of Engineering who needs financial aid should immediately consult the Director of his School. Ordinarily a single application is sufficient to assure consideration for all available scholarships and grants. When this is not true, the Director will instruct the student as to the proper procedure for making application. Scholarship applications for the following year received before April 1 will be given primary consideration. Late applications can be considered only for vacancies.

Certain grants are drawn from the income of special funds, the gifts of persons who in many instances have specified to whom in general their benefits are to apply. They are not as a rule available for aid to freshmen.

Much of the financial aid which the University is able to give undergraduate students is in the form of loans from the income of endowments which are administered for the Trustees by the standing Committee on Student Aid, of which the Counselor of Students for men is Chairman. The benefits of these funds are reserved for students

who have been in residence and in good standing at Cornell University for at least a year, and preference is given to applicants of high scholastic standing who are within a year or two of graduation.

Some of the scholarships, grants, and loan funds, donated for the special purpose of helping students in the College of Engineering, are listed below. A list of others available to students of several colleges, including engineers, is given in the *General Information Number.*

John McMullen Regional Scholarships of variable stipends up to $400 a year are available to male students in any class in the College who have been in attendance at least one term and who make superior academic records, regardless of their place of residence. Applications may be filed with the Director of the school involved at any time before April 1.

The John McMullen Undergraduate Scholarships: The Board of Trustees has established at the present time eighty of these undergraduate scholarships of an annual value of $200 each, and divided them among the four Schools of the College of Engineering. These scholarships are awarded primarily for the purpose of providing able young men with scholastic opportunities which would otherwise be denied them. They are not normally granted to Freshmen. Applications should be made to the Director of the school concerned before April 1.

The Frank William Padgham Scholarship: Open to undergraduates in the Sibley School of Mechanical Engineering or the School of Electrical Engineering. This scholarship consists of the income of a fund of $3,000 given by Amos Padgham, of Syracuse, New York, in honor of his son, Frank William Padgham, M.E. '88, and is to be applied toward the tuition and regular fees in engineering. It will be awarded to the best qualified applicant who shall have had preparatory education in the public schools of Syracuse, New York, and may be held throughout the period of the course, if the holder remains in good standing. If no candidate from Syracuse applies, it may be awarded for not more than one year to an eligible student residing elsewhere in New York. Application should be made to the Committee on Scholarships, College of Engineering, before April 1.

The Fred Lewis Wilson Scholarship: Open to undergraduates in Mechanical or Electrical Engineering. Mrs. Mary Northrup Wilson bequeathed Cornell University about $4,000 to found and perpetuate one or more scholarships in honor of her son, Fred Lewis Wilson, who was graduated from Sibley College with the class of 1892. These scholarships are awarded, for a period of not more than two years each, to undergraduates who have been at least one year in the University. Applications should be made to the Director of the school concerned before April 1.

The John Leisenring Wentz Scholarship: Open to undergraduates in Mechanical or Electrical Engineering; consists of the income of a fund of $5,500, given the University in 1920 by Mrs. Lewis Audenried in memory of John Leisenring Wentz, a member of the class of 1898. It is awarded at the end of each academic year to a member of the incoming senior class who is in need of pecuniary aid; the beneficiary must have maintained a high scholastic standing during his junior year. Applications should be made to the Director of the school concerned before April 1.

The William Delmore Thompson Scholarship: Open only to undergraduates in Mechanical Engineering; established in memory of William Delmore Thompson of the class of 1918; pays $40 a year and is for the benefit of self-supporting students of mechanical engineering. It is awarded at the beginning of the junior year, and if the student's work proves satisfactory it is continued through the senior year. Applications should be made to the Director of the School of Mechanical Engineering before April 1.

The Judson N. Smith Scholarship: Open to upperclassmen in the School of Civil Engineering; pays $160 a year, the income of a fund given by Mrs. Sarah L. Smith of Saranac Lake, New York, in memory of her son. It is awarded by the Faculty of the School of Civil Engineering at the end of each year to a student of the incoming senior or junior class in that school, of good character and scholarship and needing pecuniary aid. Applications must be made to the Director of the School of Civil Engineering before April 1.

Otto M. Eidlitz Scholarships: Open to undergraduates in the College of Engineering. These scholarships were founded in 1929 by a bequest of Otto M. Eidlitz, C.E. '81, of $25,000 to Cornell University to establish a scholarship fund in the College of Engineering for students who require financial assistance. With the avails of this bequest three scholarships of an annual value of $325 have been established. These scholarships are awarded by the Dean of the College of Engineering to such students as appear to be most deserving because of their character and intellectual promise. Applications should be made to the Director of the school concerned before April 1.

The Sylvester Edick Shaw Scholarship, the income of a fund of $4,000 given in 1929 by Sylvester Edick of Newfane, is awarded to a student designated by the alumni of Cornell University who are residents of Niagara County at the time of the award. If the alumni fail to make such designation, the award is made by the principal of the Lockport High School, preference being given to the student who is most in need of financial assistance and who is studying Mechanical or Electrical Engineering. The student has the benefit of the scholarship for the entire period of his course, provided his conduct and progress in his work are satisfactory. Applications should be made to the Committee on Scholarships, College of Engineering, before April 1.

The Joseph N. Evans Scholarship, consisting of the annual income from a bequest of $3,000 given by the will of Mrs. Joseph N. Evans in memory of her husband. Open to any undergraduate in the College of Engineering. Applications should be made to the director of the school concerned before April 1.

The Redmond Stephen Colnon Scholarships: Supported by the income from $20,000 bequeathed by Mrs. Katharene Fruin Colnon in 1935 in memory of her husband. Four scholarships of $200 each are awarded annually (two in Mechanical Engineering and one each in Civil and Electrical Engineering) to sophomores, juniors, or seniors, upon the recommendation of the school concerned. Candidates in order to be eligible must be upon the annual Honor List, and may hold the scholarships for more than one year provided they remain upon that list. Applications should be made to the director of the school concerned before April 1.

The Carl Richard Gilbert Award was founded in 1929 by Mr. and Mrs. A. S. Gilbert in memory of their son, Carl Richard Gilbert, who died during his junior year. The value of the award is about $190 annually and is available for students in the School of Electrical Engineering. Awards from this fund are made on the recommendation of the Dean of the College and the Director of the School of Electrical Engineering, and with the approval of the Faculty of Engineering, to one or more worthy students each year. Application should be made to the Director of the School of Electrical Engineering.

The William C. Seidell Book Fund of $1,425 was founded by Gerrit S. Miller. The income is used for the purchase of books for young men who are working their way through the School of Civil Engineering, and is paid upon the recommendation of the Director of the School, preference being given to underclassmen.

The Chemical Engineering Loan Fund was founded in 1938 by alumni interested in Chemical Engineering. It is available to students in the School of Chemical Engineering. Application should be made to the Director of that School.

The Robert Critchlow Dewar Loan Fund was founded in 1915, the joint gift of Mrs. James M. Dewar and the Cornell Society of Engineers, in honor of Robert Critchlow Dewar, C.E. '09. It is available to undergraduates in the School of Civil Engineering. Applications should be made to the Director of that School.

The Martin J. Insull Loan Fund was founded in 1924 by Martin J. Insull, M.E. '93, for students in the College of Engineering, and particularly those in the Sibley School of Mechanical Engineering. Application should be made to the Director of the school in which the applicant is registered.

The John N. Ostrom Loan Fund was founded in 1937 by John N. Ostrom, C.E. '77, for students in the School of Civil Engineering. Application should be made to the Director of that School.

The Wurts Loan Fund was founded by Alexander Jay Wurts in 1912, in memory of his mother, Laura Jay Wurts. It is available to students in the two upper classes of the Sibley School of Mechanical Engineering and the School of Electrical Engineering. Application should be made to the Director of the school in which the applicant is registered.

The Herman Diederichs Loan Fund was founded in 1939 by the Southern Tier Chapter of the American Society for Metals in memory of Herman Diederichs, M.E. '97, late Dean of the College of Engineering. The fund is available for loans to deserving students who have shown a genuine interest and aptitude in the field of metallurgy. Application should be made to the Director of the school in which the applicant is registered.

The Samuel Wiley Wakeman Loan Fund of $10,000 was bequeathed in 1940 by Samuel Wiley Wakeman, M.E. '99, whose will directed that the gift be held as a permanent fund, the income of which is to be loaned to male members of the second year class of the Sibley School of Mechanical Engineering. Applications should be made to the Director of the Sibley School of Mechanical Engineering.

The Lillian S. Mennen Memorial Fund, founded in 1937 by William G. Mennen, M.E. '08, as a memorial to his mother, provides loans preferably to juniors and seniors majoring in Chemistry (in the College of Arts and Sciences), Chemical Engineering, and Administrative Engineering,

from the State of New Jersey; otherwise to other engineering students who are exceptionally qualified. Applications should be made to the Director of the school in which the student is registered.

PRIZES Cornell University has a considerable number of funds given for the endowment of prizes to be awarded annually. Some of these prizes are open to competition by students of the University generally. The Secretary of the University publishes a list of them under the title *Prize Competitions*, a copy of which will be mailed on request addressed to his office. Other prizes are open to competition particularly by students of the College of Engineering, as follows:

The Fuertes Medals, established by the late Professor E. A. Fuertes. The endowment provides for two gold medals. One is awarded annually by the Faculty to that student of the School of Civil Engineering who is found at the end of the first term of his senior year to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance at the University for at least two years. The other is awarded annually by the Faculty to a graduate of the School of Civil Engineering who has written a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15. If a paper is presented in printed form it will not be received if it has been printed earlier than the next preceding April 15. Neither medal is awarded unless it appears to the Faculty of the School of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction.

The Fuertes Memorial Prizes in Public Speaking, founded by the late Charles H. Baker, a graduate of the School of Civil Engineering of the class of 1886. Three prizes, one of $80, one of $40, and one of $20, are offered annually to members of the Junior and Senior classes in the Colleges of Engineering and Architecture for proficiency in public speaking.

The Charles Lee Crandall Prizes, founded in 1916 by alumni of the School of Civil Engineering; prizes of $75, $50, $35, and $20. They are awarded each year, by a committee appointed by the Director of the School of Civil Engineering, for the best papers written by seniors or juniors in that school on suitable subjects, provided that both the substance and the written form of the papers submitted show real merit. The prizes were established to encourage original research, to stimulate interest in matters of public concern, and to inspire in the students an appreciation of the opportunities which the profession of civil engineering offers them to serve their fellow men as intelligent and public-spirited citizens. Papers must be submitted to the Director of the School of Civil Engineering on or before May 1 of each year.

The Sibley Prizes in Mechanic Arts are offered to undergraduates in Mechanical and Electrical Engineering. Under a gift of Hiram Sibley, made in 1884, the sum of $100 is awarded annually in several prizes to juniors and seniors in the School of Mechanical Engineering and in the School of Electrical Engineering who have received the highest marks in scholarship in at least three full terms of work.

The J. G. White Prize in Spanish. Through the generosity of James Gilbert White (Ph.D., Cornell, '85) three prizes, established in 1914, each of the value of $100, are offered annually. One of the three, which is awarded to an English-speaking student for proficiency in Spanish, is open to members of the junior and senior classes in the College of Engineering who are candidates for their first degree. No candidate is eligible unless he has completed successfully two terms of work in Spanish at Cornell University.

The Robert Harris Simpson Prize, founded in 1933 by Mrs. Simpson in memory of her late husband, Robert Harris Simpson, C.E. '96. This prize of $25 is awarded annually to that senior in the School of Civil Engineering who submits the best technical description or design of a civic improvement of sufficient substance and merit to justify the award. Papers or designs must be submitted on or before December 15 of each year and are judged by a committee appointed by the Director of the School of Civil Engineering.

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School of Civil Engineering

THE COURSES OF STUDY

The courses of study offered by the School of Civil Engineering leading to the degree of Bachelor of Civil Engineering or to that of Bachelor of Science in Administrative Engineering are planned to provide fundamental instruction necessary for the practice of the profession. They all contain training in those subjects which the Faculty considers essential. Great latitude is given to provide for liberalization in the regular course, while a series of optional courses of study is offered as a guide to those who have the desire to add further to their fundamental preparation in any of the several branches of civil engineering. All of these technical optional courses of study have a common background to technical courses paralleling those of the regular course; so that a student electing to follow one of the technical options will also be well prepared in the other branches of civil engineering.

A student may defer election of an Option until the beginning of the junior year. The same sequence of dependent courses must be followed.

A student desiring to specialize in a field requiring it may, subject to the approval of his class adviser, defer certain junior courses of instruction, not fundamental or prerequisite to the senior work, until the senior year, in order to take elective or required courses of the senior year in the junior year. A student may not, however, anticipate the work of the curriculum by more than one year.

SPECIAL REQUIREMENTS

Not more than four hours credit for elective work in Advanced Military Science and Tactics will be accepted toward meeting the degree requirements. However, in the case of the Administrative, Structural, and Transportation Engineering Options and the B.S. in A.E. Course, each of which provides for only three elective hours, not more than three hours of credit in Advanced Military Science and Tactics may be used toward the degree requirement. Such credit may not be used toward the degree in case of the Sanitary Engineering and Hydraulic Engineering Options, where electives are restricted.

An organized inspection trip during the second semester is required of all juniors in Civil Engineering except those excused by the Director and is optional for seniors and graduates. The trip is in charge of a

faculty committee and the student is required to write and submit a satisfactory report to the committee. A fee of $25 is charged each student for this trip. This fee is payable early in March.

The next following pages contain outlines of the several courses and options in the School of Civil Engineering.

THE FRESHMAN YEAR

A single schedule of courses of instruction is prescribed for all members of the Freshman class in the School of Civil Engineering. This prescribed schedule is outlined below. Each course of instruction is numbered and will be found described under that number on one of the following pages.

REQUIRED COURSES OF INSTRUCTION	HOURS *First Term*	HOURS *Second Term*
Analytical Geometry and Calculus 55a, 55b	5	5
General Physics 11, 12	4	4
General Chemistry 102 or 104	3	3
Drawing 200, 201	3	3
Elementary Surveying 210	3 or 0	0 or 3
Metal Working 3S11	0 or 1	1 or 0
Introductory Lectures 209	1	0
Hygiene 1, 2	1	1
Total number of hours a term	20 or 18	17 or 19

In addition to taking the above courses all freshmen must satisfy the University's requirement of three hours a week throughout the year in Military Science and Tactics (see the *General Information Number*).

The courses in Mathematics, Physics, and Chemistry are given in the College of Arts and Sciences. All the others except Hygiene and Military Science are given in the College of Engineering.

THE SECOND YEAR

The schedules of courses in the second year are the same for all options and for the course for B.S. in A.E.

SECOND YEAR 37 HOURS	Public Speaking I	3 or 0	0 or 3
	Engineering Geology 501	0 or 3	3 or 0
	The Elements of Field Astronomy 182	0	2
	Drawing 203	0	2
	Descriptive Geometry 204	3	0
	Advanced Surveying 211	3	0
	Mechanics of Engineering 220	5	0
	Mechanics Laboratory and Computations 220-A, 220-B	2	0
	Mechanics of Engineering 221	0	4
	Mechanics Laboratory 221-A	0	1
	Route Surveying and Drawing 260-B	0	3
	Engineering Construction 264	3 or 0	0 or 3
	English 2	0 or 3	3 or 0
	In addition to these courses, sophomores are required to take Military Training.		
SUMMER COURSES 5 HOURS	Summer Survey 213 (four weeks in summer vacation)		4
	Location Surveying 260-A (one week in summer vacation)		1

1. The Regular Four-Year Course

	(FOR THE DEGREE OF B.C.E.)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 34 HOURS	Introduction to Economics, Economics 3	3 or 0	0 or 3
	Materials of Construction 225	0 or 3	3 or 0
	Materials Laboratory 226	0 or 3	3 or 0
	Hydraulics 240	4	0
	Sewerage and Sewage Treatment 252	0	3
	Treatment of Water 253-A	0	2
	Engineering Management 293	3 or 0	0 or 3
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Concrete Construction 280	0 or 3	3 or 0
	Soil Mechanics 287	3 or 0	0 or 3
FOURTH YEAR 35 HOURS	Heat-Power Equipment 3P43	0	3
	Electrical Equipment 418	3	0
	Engineering Problems 223	0	2
	Water Supply 230	0 or 3	3 or 0
	Highway Engineering 265	3 or 0	0 or 3
	Foundations 281	3 or 0	0 or 3
	Engineering Law 290	0 or 3	3 or 0
	Elective*	9	6
	Grand total for the Four-Year Course		148 hours

*Of the elective hours, at least six must be taken in the School of Civil Engineering. The elective courses taken outside the School of Civil Engineering must be selected from among those not open to freshmen, unless the course selected has the special approval of the class adviser. See also page 60.

2. Administrative Option

(FOR THE DEGREE OF B.C.E)

(For the Administrative Engineering Course, see page 69)

		HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 35 HOURS	Introduction to Economics, Economics 3	0	3
	Business and Industrial Management 3A23	4	0
	Principles of Industrial Accounting and Cost Finding 3A31	0	3
	Engineering Management 293-A	0	3
	Materials of Construction 225	3	0
	Materials Laboratory 226	3	0
	Concrete Construction 280	3	0
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Hydraulics 240	0	4
	Treatment of Water 253-A	0	2
FOURTH YEAR 35 HOURS	Money and Credit, Economics 11	3	0
	Corporation Finance, Economics 31	0	3
	Engineering Law 290	0	3
	Sewerage and Sewage Treatment 252	3	0
	Engineering Problems 223	2	0
	Water Supply 230	3	0
	Highway Engineering 265	0	3
	Heat-Power Equipment 3P43	0	3
	Electrical Equipment 418	3	0
	Foundations 281	0	3
	Elective*	3	3

Grand total for the Four-Year Course ..... 149 hours

*Any of the following courses may be taken profitably as an elective: Industrial Combinations, Ec. 32; Public Utilities, Ec. 33; Transportation, C.E. 269; Advanced Engineering Law, C.E. 290 A; Valuation Engineering, C.E. 295; Municipal Administrative Engineering, C.E. 256. See also page 60.

3. Sanitary Engineering Option

	(FOR THE DEGREE OF B.C.E.)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 34 OR 35 HOURS	Introduction to Economics, Economics 3	0	3
	Stress Analysis and Structural Design 270	4	0
	Hydraulics 240	4	0
	Sewerage and Sewage Treatment 252	3	0
	Treatment of Water 253-A	0	2
	Concrete Construction 280	0	3
	Materials of Construction 225	3	0
	Materials Laboratory 226	0	3
	Sanitary Biology 250	0	3
	Sanitary Biology 251	2	0
	Water and Sewage Analysis 258	2	0
	Elective Sanitary Engineering Courses*	0	2 or 3
	*From Course 256-B—credit 2 hours, or Course 256-A—3 hours.		
FOURTH YEAR 36 HOURS	Electrical Equipment 418	3	0
	Heat-Power Equipment 3P43	0	3
	Water Supply 230	0	3
	Highway Engineering 265	0	3
	Engineering Law 290	0	3
	Foundations 281	0	3
	Structural Design 271	3	0
	Sewerage Works 254	3	0
	Control and Treatment of Water Supplies 253	0	3
	Treatment of Wastes 255	3	0
	Soil Mechanics 287	3	0
	Elective Sanitary Engineering Course or Courses†	3	0
	†Any desirable combination of the following: 256-A, 256-B, 257, 258, 259, 291d, 297d.		

Grand total for the Four-Year Course ..... 149 or 150 hours

4. Structural Engineering Option

	(FOR THE DEGREE OF B.C.E)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 34 HOURS	Introduction to Economics, Economics 3	0 or 3	3 or 0
	Materials of Construction 225	3 or 0	0 or 3
	Materials Laboratory 226	3 or 0	0 or 3
	Hydraulics 240	0 or 4	4 or 0
	Advanced Mechanics 222	0	3
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Concrete Construction 280	3 or 0	0 or 3
	Foundations 281	3	0
	Soil Mechanics 287	0 or 3	3 or 0
	Treatment of Water 253-A	0	2
FOURTH YEAR 36 HOURS	Water Supply 230	0	3
	Highway Engineering 265	0	3
	Engineering Law 290	0	3
	Electrical Equipment 418	3	0
	Heat-Power Equipment 3P43	0	3
	Sewerage and Sewage Treatment 252	3	0
	Advanced Structural Analysis 272	3	0
	Fixed Arches 283	3	0
	Engineering Mathematics 224-A	3	0
	Bridge Design 274 or Highway Bridges 284	0	3
	Reinforced Concrete Design 285	3	0
	Elective	0	3

Grand total for the Four-Year Course ..... 149 hours

5. Hydraulic Engineering Option

	(FOR THE DEGREE OF B.C.E.)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 34 HOURS	Introduction to Economics, Economics 3	0 or 3	3 or 0
	Hydraulics 240	4	0
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Sewerage and Sewage Treatment 252	0	3
	Treatment of Water 253-A	0	2
	Materials of Construction 225	3 or 0	0 or 3
	Materials Laboratory 226	3 or 0	0 or 3
	Concrete Construction 280	3 or 0	0 or 3
	Foundations 281	0 or 3	3 or 0
	Soil Mechanics 287	0 or 3	3 or 0
FOURTH YEAR 37 HOURS	Heat-Power Equipment 3P43	0	3
	Electrical Equipment 418	3	0
	Water Supply 230	3	0
	Engineering Law 290	3	0
	Highway Engineering 265	0	3
	Hydraulic Measurements 242	3	0
	Hydraulic Construction 231	0	3
	Hydraulic Group Options*	3	3
	Elective	3	6

Grand total for the Four-Year Course ..... 149 hours

*From Courses Water-Power 232, Hydraulic Engineering 233, Conservancy and Reclamation Problems 234, Water-Power and Pumping Plants 236, Engineering Mathematics 224-A, Hydrodynamics, Physics 451 and 452, Advanced Hydraulics 241, Hydraulic Engineering Design 291 (c), Hydraulics Research 297 (c), Thesis 298.

6. Transportation Engineering Option

	(FOR THE DEGREE OF B.C.E.)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 35 HOURS	Introduction to Economics, Economics 3	3	0
	Materials of Construction 225	0 or 3	3 or 0
	Materials Laboratory 226	0 or 3	3 or 0
	Hydraulics 240	4 or 0	0 or 4
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Concrete Construction 280	0 or 3	3 or 0
	Foundations 281	3 or 0	0 or 3
	Soil Mechanics 287	0	3
	Route Location 263	0	3
	Engineering Management 293	3 or 0	0 or 3
FOURTH YEAR 37 HOURS	Heat-Power Equipment 3P43	0	3
	Engineering Problems 223	0	2
	Engineering Law 290	3	0
	Transportation 269	0	3
	Electrical Equipment 418	3	0
	Valuation Engineering 295	0	3
	Highway Engineering 265	3	0
	Highway Laboratory 266 *or* Railroad Maintenance of Way 261	3	0
	Advanced Highway Engineering 267 *or* Railroad Operation and Management 262	0	3
	Sewerage and Sewage Treatment 252	3	0
	Treatment of Water 253-A	0	2
	Water Supply 230	3	0
	Elective	0	3

Grand total for the Four-Year Course ..... 151 hours

7. Geodetic Engineering Option

	(FOR THE DEGREE OF B.C.E.)	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 34 HOURS	Introduction to Economics, Economics 3	3	0
	Materials of Construction 225	0	3
	Materials Laboratory 226	0	3
	Hydraulics 240	4	0
	Sewerage and Sewage Treatment 252	0	3
	Treatment of Water 253-A	0	2
	Engineering of Management 293	3	0
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Concrete Construction 280	0	3
	Mapping 214	2	0
	Topographic Surveying 214-A	1	0
FOURTH YEAR 35 HOURS	Heat-Power Equipment 3P43	0	3
	Electrical Equipment 418	3	0
	Engineering Problems 223	0	2
	Water Supply 230	0	3
	Highway Engineering 265	3	0
	Engineering Law 290	3	0
	Problems in the Adjustment of Observations 215	1	0
	Least Squares: Adjustment of Observations 216	2	0
	Geodesy and Geodetic Laboratory 198	3	0
	Photographic and Aerial Surveying 219	0	3
	Foundations 281	0	3
	Elective	3	3

Grand total for the Four-Year Course ..... 148 hours

A Four-Year Course (B.S. in A.E.)

A four-year course leading to the degree of Bachelor of Science in Administrative Engineering is given in the School of Civil Engineering. The requirements for admission are the same as for the regular course leading to the degree of Bachelor of Civil Engineering. An outline of this course in Administrative Engineering follows. (See also the Administrative Option, page 63.)

		HOURS	
		First Term	*Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See The Second Year, page 61	19	18
SUMMER COURSES 5 HOURS	See page 61		5
THIRD YEAR 36 HOURS	Materials of Construction 225	3	0
	Materials Laboratory 226	3	0
	Hydraulics 240	0	4
	Engineering Management 293-A	0	3
	Stress Analysis 270	4	0
	Structural Design 271	0	3
	Concrete Construction 280	3	0
	Treatment of Water 253-A	0	2
	Sewerage and Sewage Treatment 252	0	3
	Business and Industrial Management 3A23	4	0
	Introduction to Economics, Economics 3	0	3
FOURTH YEAR 35 HOURS	Money and Credit, Economics 11	3	0
	Water Supply 230	0	3
	Highway Engineering 265	3	0
	Engineering Law 290	3	0
	Advanced Engineering Law 290-A	0	3
	Principles of Industrial Accounting and Cost Finding 3A31	3	0
	Transportation 269	0	3
	Valuation Engineering 295	0	3
	Municipal Administrative Engineering 256	3	0
	Electrical Equipment 418	3	0
	Heat-Power Equipment 3P43	0	3
	Corporation Finance, Economics 31	0	3
	Grand total for the Four-Year Course		150 hours

A Five-Year Course (B.C.E. and B.S. in A.E.)

A five-year course of study is offered, so arranged that the degree of B.C.E. may be obtained at the end of the fourth year and that of B.S. in A.E. at the end of the fifth. Declaration of intention to take this course should be made at the beginning of the second year.

		HOURS	
		First Term	*Second Term*
FIRST YEAR 37 HOURS	See The Freshman Year, page 61	20 or 18	17 or 19
SECOND YEAR 37 HOURS	See Second Year, page 61	19	18
	(Sophomores are required to take Military Training.)		
SUMMER COURSES 5 HOURS	Summer Survey 213 (four weeks in summer vacation)		4
	Location Surveying 260A (one week in summer vacation)		1
THIRD YEAR 35 HOURS	Introduction to Economics, Economics 3	0	3
	Business and Industrial Management 3A23	4	0
	Principles of Industrial Accounting and Cost Finding 3A31	0	3
	Engineering Management 293-A	0	3
	Materials of Construction 225	3	0
	Materials Laboratory 226	3	0
	Concrete Construction 280	3	0
	Stress Analysis and Structural Design 270	4	0
	Structural Design 271	0	3
	Hydraulics 240	0	4
	Treatment of Water 253-A	0	2
FOURTH YEAR 35 HOURS	Money and Credit, Economics 11	3	0
	Corporation Finance, Economics 31	0	3
	Engineering Law 290	0	3
	Sewerage and Sewage Treatment 252	3	0
	Engineering Problems 223	2	0
	Water Supply 230	3	0
	Highway Engineering 265	0	3
	Heat-Power Equipment 3P43	0	3
	Electrical Equipment 418	3	0
	Foundations 281	0	3
	Soil Mechanics 287	3	0
	Elective	0	3
	Grand total for the Four-Year Course		149 hours
FIFTH YEAR 36 HOURS	Psychotechnology in Business and Industry, Psychology 8	0	3
	Advanced Engineering Law 290-A	0	3
	Transportation 269	0	3
	Valuation Engineering 295	0	3
	Municipal Administrative Engineering 256	3	0
	Public Control of Business, Economics 32a	3	0
	Taxation, Economics 36	0	3
	Labor Conditions and Problems, Economics 41	3	0
	Elective*	9	3
	Grand total for the Five-Year Course		185 hours

*At least nine hours of elective work must be taken in subjects of engineering or administrative character, as approved by the class adviser.

A Six-Year Course (A.B. and B.C.E. or B.S. in A.E.)

For a course leading to the degree of A.B. at the end of four years and to that of B.C.E. or of B.S. in A.E. at the end of six years, a student on entrance must satisfy all the requirements for entrance of the College of Arts and Sciences in which he registers until he receives his first degree. In the last two years he will register in the School of Civil Engineering.

While in the College of Arts and Sciences the student must complete all of his entrance requirements for Engineering before the end of the second year and must complete all his first and second year subjects of the Civil Engineering curriculum before the end of the fourth year, that is, his last year in the College of Arts and Sciences.

Any advice on the arrangement of such courses will be given by the Director of the School of Civil Engineering. A possible arrangement of such a six-year course is given below, but other arrangements may be made if more suitable.

COURSE LEADING TO THE DEGREES OF A.B. AND B.C.E.

		HOURS	
		First Term	*Second Term*
FIRST YEAR 32 HOURS	Mathematics 7a, 7b	3	3
	Chemistry 102 or 104	3	3
	English	3	3
	Foreign Language	3	3
	History	3	3
	Metal Working 3S11	0	1
	Introductory Lectures 209	1	0
SECOND YEAR 32 HOURS	Mathematics 7c, 7d	3	3
	Physics 11, 12	4	4
	Drawing 200, 201	3	3
	Public Speaking 1	3	0
	Surveying 210	0	3
	A. & S. major and electives	3	3
THIRD YEAR 34 HOURS	Economics 1	0	5
	Surveying 211	3	0
	Route Surveying 260B	0	3
	Mechanics 220, 220A, 220B	7	0
	Mechanics 221, 221A	0	5
	Astronomy 182	0	2
	A. & S. major and electives	6	3
FOURTH YEAR 35 HOURS	Drawing 204, 203	3	2
	Engineering Construction 264	0	3
	Engineering Geology 501	3	0
	Engineering electives	0	3
	A. & S. major and electives	12	9
SUMMER COURSES	Summer Survey 213		4
	Location Surveying 260 A		1

FIFTH and SIXTH YEARS as in C.E. Options, above.

The Courses of Instruction

The courses of instruction described in the following pages are those normally taken by students in the School of Civil Engineering. The courses in Chemistry, Geology, Economics, English, Mathematics, Physics, Psychology, and Public Speaking are given in the College of Arts and Sciences.

CHEMISTRY

102. *General Chemistry*. See page 164.
104. *General Chemistry*. See page 165.

GEOLOGY

501. *Engineering Geology*. Required of all sophomores in Civil Engineering. Either term. Credit three hours. The practical application of geologic principles and the occurrence of such economic materials as are of importance to engineering students, the whole subject being treated with reference to their needs. Lectures and laboratory work. Fee, $4.50. *McGraw Hall*. Associate Professor ANDERSON.

ECONOMICS

3. *Introduction to Economics*. Required of all juniors in Civil Engineering. Either term. Credit three hours. An introduction to the more essential economic features of contemporary American society. *Goldwin Smith Hall*. Professor O'LEARY.

11. *Money and Credit*. Required for Administrative Option and B.S. in A.E. Course in Civil Engineering. Elective for others. Either term. Credit three hours. Prerequisite, Economics I or its equivalent. An introductory study of the history and the theory of money, currency, and bank credit. *Goldwin Smith Hall*. Professor REED.

31. *Corporation Finance*. Required of juniors or seniors in Administrative Option and B.S. in A.E. Course in Civil Engineering. Either term. Credit three hours. Prerequisite, course 3A31, Accounting for Engineers.

A study of the financial practices of business corporations in the United States: types of corporate securities; sources of capital funds; determination and administration of corporate funds; determination and administration of corporate incomes; financial difficulties and corporate reorganizations; the relation of corporate practices to the functioning of the American economic system; and the regulatory activities of the Securities and Exchange Commission. *Goldwin Smith Hall*. Professor O'LEARY.

ENGLISH

English 2. Required of all sophomores in Civil Engineering. Either term. Credit three hours. The aim of the course is to increase the student's ability to communicate his own thoughts and understand the thoughts of others. Professor BROWN and others.

MATHEMATICS

55a, 55b. *Analytical Geometry and Calculus*. See page 165.

PHYSICS

11, 12. *General Physics.* See page 165.

PUBLIC SPEAKING

Public Speaking 1. Required of all sophomores in Civil Engineering. Either term. Credit three hours. Designed to give the student the fundamentals of speech preparation and to help him acquire a simple, direct manner of speaking. Original speeches and interpretation of selections. *Goldwin Smith Hall.* Professor WICHELNS.

MECHANICAL ENGINEERING

3S11. *Metal Working.* See page 132.

3A23. *Business and Industrial Management.* Required of juniors in the Administrative Engineering Option and the B.S. in A.E. Course in Civil Engineering. Either term. Credit four hours. For a description of this course, see page 118. Professor BANGS.

3A31. *Principles of Industrial Accounting and Cost Finding.* Required of juniors in the Administrative Option and the B.S. in A.E. course in Civil Engineering. Either term. Credit three hours. Two recitations and one 2½-hour computing period a week. *West Sibley.* For a description of this course, see page 118. Professor BANGS and others.

3P43. *Heat-Power Equipment.* Required of all seniors in Civil Engineering. Second term. Credit three hours. For a description of this course see page 130 of this Announcement. *West Sibley.* Professor ELLENWOOD.

3P43A. *Heat-Power Engineering.* This course is given for U. S. Army Engineers taking graduate work at Cornell. Second term. The work will deal chiefly with the operation, performance characteristics, first cost, and operating cost of spark-ignition engines, compression-ignition engines, steam turbines, steam engines, steam boilers, air compressors, and pumps. Two lectures and one laboratory period a week. Inspection trips are also required. See page 130. Professors ELLENWOOD and DAVIS.

ELECTRICAL ENGINEERING

418. *Electrical Equipment.* Required of all seniors in Civil Engineering. First term. Credit three hours. *Franklin Hall.* Professor BALLARD. For description of this course see page 149 of this Announcement.

ASTRONOMY

182. *The Elements of Field Astronomy.* Required of Civil Engineering sophomores. Second term. Credit two hours. Prerequisite, Surveying 210 (or Astronomy 180 and Mathematics 3). The determination of time, latitude, longitude, and azimuth by observations on the sun and stars using a surveyor's transit and a watch. Textbooks: *Textbook of Practical Astronomy* by Nassau and *Determination of Azimuth, Time, and Latitude* by Boothroyd. One one-hour recitation and one two-hour laboratory period a week, some of the laboratory periods being in the late afternoon and at night for observations on sun and stars. Professor BOOTHROYD.

183. *Navigation and Nautical Astronomy*. Elective. Either term. Credit three hours. Prerequisite, Mathematics 3. Position of a ship or airplane by dead reckoning and by astronomical observation, with laboratory exercises, using sextant to determine time, latitude, and longitude. Students who already have two hours credit for Course 182 will get one hour additional credit upon completion of the extra work necessary to obtain credit for Course 183. Civil Engineering sophomores may take this course instead of Course 182 and count the extra hour credit as a Civil Engineering Elective. Textbooks: *The Essentials of Modern Navigation*, by Wylie and *Textbook of Practical Astronomy* by Nassau. Each student should have access to a copy of the *American Nautical Almanac* for the year. Lectures and recitations M at 10 with two two-hour laboratory periods a week to be arranged. Some of the laboratory and recitation periods during several weeks of the term are used for sextant observations of the sun during the day and of the moon, stars, and planets at night. This course should be of special interest to those who contemplate becoming aviators or navigators. Professors BOOTHROYD and SHAW.

186. *Geodetic Astronomy*. Elective. Either term. Credit three hours. Prerequisites, Astronomy 182 and Advanced Surveying 211 (or Mathematics 4a and 4b and General Astronomy 187) or approved equivalents. The theory and practice of the precise determination of time, latitude, longitude, and azimuth. Figure of the Earth and Isostacy will also be considered. Textbook: Hosmer's *Geodesy*, Second Edition. Lecture and discussion, one hour a week and evening observing at the Observatory together with the reduction of observations which will average about 5 hours a week throughout the term. The laboratory work may be spread throughout the year if it seems desirable to do so. Professor BOOTHROYD.

DESCRIPTIVE GEOMETRY AND DRAWING

200. *Drawing*. First term. Credit three hours. Use of drawing instruments, free-hand lettering, titles, geometrical problems, simple orthographic projection, technical sketching. Textbook: French's *Engineering Drawing*. Assistant Professors JENKINS, PERRY, THATCHER, and Mr. SPRY.

201. *Drawing*. Second term. Credit three hours. Orthographic projection, sections, scale drawings, practical problems, tracing, blueprinting, conventional signs, topographic mapping, isometric drawing. Textbook: French's *Engineering Drawing*. Assistant Professors JENKINS, PERRY, THATCHER, and Messrs. SPRY and PRIEST.

203. *Drawing*. Required of all sophomores in Civil Engineering. Second term. Credit two hours. Lettering, with practice in forming letters and combining them into appropriate titles; projections and intersections of practical problems; structural detailing and tracing; reading engineering drawings. Textbook: French's *Engineering Drawing*. Assistant Professors JENKINS, PERRY, THATCHER, and Mr. SPRY.

204. *Drawing*. Required of all Civil Engineering sophomores. First term. Credit three hours.

Instruction and drill in the fundamental conceptions of descriptive geometry, including orthographic projection and representation of the point, line, and plane. A study of the sections, developments, and intersections of surfaces and solids with applications in practical problems. Textbook: Rowe's *Engineering Descriptive Geometry*. Assistant Professor JENKINS.

205. *Advanced Drawing.* Elective. Juniors and seniors. Second term. Credit one to three hours. Perspective drawings, rendered in pencil, ink, and washes, of buildings, concrete bridges, dams, and other engineering works; building details of window frames, doors, stairs, and other simple units, to give the student some insight into detailing parts of plans, and further to familiarize him with reading working drawings. Problems in concrete, structural, topographical, highway, and sanitary drafting; engineering drawings, rendered in color, to enable the student to supplement ordinary working drawings with artistic representations so portrayed as to be readily intelligible to non-technical persons. Assistant Professor JENKINS.

ORIENTATION

209. *Introductory Lectures.* Freshmen. Credit one hour. One lecture a week. This course of lectures is designed to introduce the first-year men to the various fields of civil engineering, and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lectures to awaken the interest of the freshmen in their chosen profession through the aid of vivid description, of stimulating biography, and of personal experience.

SURVEYING

210. *Elementary Surveying.* Required of freshmen in Civil Engineering. Either term as assigned. Credit three hours. Use of steel tape, level, and transit; fundamental surveying methods; measurements of lines, angles, and differences of elevation; land surveying, areas and plotting. Textbook: Breed and Hosmer's *Elementary Surveying.* First term, one recitation and two field, computation, or mapping periods a week. Second term, three recitation periods a week for the first six weeks and three field, computation, or mapping periods a week during the remainder of the term. Professor UNDERWOOD, Assistant Professor LAWRENCE, and Mr. SPRY.

210-A. *Elementary Surveying.* Required of freshmen in Mechanical and Electrical Engineering. Either term. Credit one hour. Use of steel tape, level and transit. Fundamentals. Problems of particular interest to Mechanical and Electrical Engineering. Textbook: *Surveying,* Breed. One 2½-hour period a week. Professor UNDERWOOD, Assistant Professors LAWRENCE, CRANDALL, THATCHER, and Mr. SPRY.

211. *Advanced Surveying.* Required of all sophomores in Civil Engineering. First term. Credit three hours. Prerequisite, Elementary Surveying 210. City and mining surveying; surveys of the United States public lands; rectangular coordinate systems for cities and states; volumetric, topographic, hydrographic, and geodetic surveying; transit, stadia and plane table surveys; sextant; soundings, triangulation; base lines; precise and trigonometric leveling; elements of photographic surveying; map projections. Textbooks: Breed and Hosmer's *Elementary Surveying,* Vol. I, and *Higher Surveying,* Vol. II. Two recitations and one field period a week during the first half of the term, and three recitations a week during the remainder of the term. Professor UNDERWOOD and Assistant Professor LAWRENCE.

212. *Advanced Surveying.* For students in Landscape Architecture. Second term in alternate years. Not given in 1942–43. Credit two hours. Prerequisite Elementary Surveying 210 or 210-A. Profile leveling; cross-sectioning; earth-

work; circular curves and spirals; vertical curves. Textbook: Breed and Hosmer's Vol. I, *Elementary Surveying*. Recitations, computation, and field work. Assistant Professor LAWRENCE.

213. *Summer Survey:* (Topographic, Hydrographic, and Geodetic Survey Camp.) Required of all Civil Engineering students, following the sophomore year. Credit four hours for course 213 and one hour for course 260-A. Prerequisite Advanced Surveying 211. Practical experience in surveying under field conditions. An extensive topographic survey with the transit and stadia and the plane table, and a hydrographic survey of a portion of Cayuta Lake are executed, and field maps are made. Triangulation and precise leveling control the topographic and hydrographic work. A base line is measured with invar tapes. Solar observations for azimuth and time are made and results computed. Each student takes part in all branches of the work. Field and office work six days a week. Attendance for four weeks is required for course 213 (four hours credit) and one week for course 260-A (one hour credit; see page 85 for description of this course). Date of beginning of the camp will be announced in the second term. Professors UNDERWOOD and BOOTHROYD, Assistant Professors LAWRENCE, PERRY, THATCHER, and Mr. SPRY.

214. *Mapping*. Elective for upperclassmen and required for juniors in the Geodetic Engineering Option in Civil Engineering. First term. Credit two hours. The construction of a final topographic map of the area covered by the field work of Course 213 during the preceding summer. The field sheets are combined for this purpose, reduced in scale from 1:4800 to 1:12000, and reproduced, using the triangulation system as a base for the work. Lectures and drawing. Two laboratory periods a week. Professor UNDERWOOD.

214-A. *Topographic Surveying*. Required for juniors taking the Geodetic Engineering Option in Civil Engineering, elective for others. First term. Credit one hour. Prerequisite courses 211 and 213. Methods of making topographic surveys for mapping to a large scale. The use of the plane table in such surveys. Solutions of the three-point problem; two-point problem; location of details by direction and distance. Field work and mapping. One field or drawing period a week. Professor UNDERWOOD.

215. *Problems in the Adjustment of Observations*. Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. First term. Credit one hour. Prerequisite, course 213. A series of examples in the adjustment of typical surveying work such as leveling, direct measurement of lines and angles, and simple triangulation figures, using the methods of least squares. Lectures and problems. Professor UNDERWOOD.

216. *Least Squares: Adjustment of Observations*. Required of seniors taking the Geodetic Engineering Option in Civil Engineering, elective for others. First term. Credit two hours. Prerequisites, Calculus and Physics. The course is designed for students who have experimental investigations in view. Applications are made to problems in physics, astronomy, mechanics, hydraulics, surveying, etc., with some attention given to the derivation of empirical formulae. Textbook: Leland's *Practical Least Squares*. Two recitations and lectures a week, as may be arranged. Professor UNDERWOOD.

217. *Advanced Topographic Surveying*. Elective. Upperclassmen. Second term. Credit two hours. Prerequisite, course 213. Economics of surveying methods. Surveys for special purposes, such as extensive construction work, storage

and distribution of water for irrigation; earthwork on a large scale, lines of communication, topographic reconnaissance, etc.; photographic surveying. Lectures, recitations, and assigned readings. Two hours a week. Professor UNDERWOOD.

218. *Geodesy and Geodetic Laboratory.* Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisites, courses 182 and 211. A course for the consideration of special problems in geodetic work. Precise leveling, deflection of the plumb line, figure of the earth, use and investigation of geodetic instruments and apparatus such as circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods a week. Professor UNDERWOOD.

219. *Photographic and Aerial Surveying.* Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, Advanced Surveying 211. The principles of photographic surveying; surveys with camera stations on the ground, including stereoscopic methods; aerial surveys and making of maps from such surveys; ground control. Recitations, lectures, and collateral reading. Three hours a week. Professor UNDERWOOD.

For *Research in Geodetic Engineering*, see course 297i.

MECHANICS OF ENGINEERING

220. *Mechanics of Engineering.* Required of all Civil Engineering sophomores. First term. Repeated in one section, second term, if there are sufficient students. Credit five hours. Prerequisite course, Mathematics 55b. (See Courses 220-A and 220-B below.) Statics of a material point and of rigid bodies and structures by algebraic and by graphic methods of analysis; chains and cords; centers of gravity; moments of inertia; kinetics and dynamics of a material particle; centrifugal and centripetal forces; dynamics of collections of material particles forming rigid bodies; pendulums; friction, work, power, measurement of power; the general theorem of work and energy applied to collections of rigid members forming machines; impact, impulse, and momentum. Emphasis is placed upon the theory as well as upon the use of consistent units and correct numerical work. Facility in the use of the slide rule is essential. Textbook: Seeley and Ensign, *Analytical Mechanics for Engineers.* Five recitations a week. Assistant Professors HOWELL, CUYKENDALL, GIFFT, and Mr. PRIEST.

220-A. *Mechanics Laboratory.* Required of Civil Engineering sophomores. First term. Credit one hour. Courses 220, 220-A, 220-B are closely correlated and should be taken concurrently. This course consists of experiments (both qualitative and quantitative) designed to illustrate the principles of mechanics covered in Course 220. In general the experiments are performed by the students themselves, and a complete, well-arranged report on each experiment is required of each student. Instruction in the use of the slide rule and of the planimeter is included in the work. One two and one-half hour period a week in the laboratory. Assistant Professors HOWELL, CUYKENDALL, GIFFT, and Mr. PRIEST.

220-B. *Mechanics Computations.* Required of Civil Engineering sophomores. First term. Credit one hour. To be taken with Course 220. Devoted to the solution of problems related to the topics covered concurrently in Course 220. One computation period of two and one-half hours a week under instruction. Assistant Professors HOWELL, CUYKENDALL, GIFFT, and Mr. PRIEST. CUYKENDALL, GIFFT, and Mr. PRIEST.

221. *Mechanics of Engineering.* Required of Civil Engineering sophomores. Second term. Repeated in one section, first term, if there are sufficient students. Credit four hours. Continuation of Mechanics 220. Prerequisite course, Mechanics 220. Mechanics of materials including stress and strain, tension, shearing, compression, torsion, flexure; elastic curves; safe loads; columns; flexure of beams by semigraphic treatment. Review problems showing application of principles in Engineering Design. Textbook: George & Rettger, *Mechanics of Materials.* Four recitations a week. Assistant Professors HOWELL, CUYKENDALL, GIFFT, and Mr. PRIEST.

221-A. *Mechanics Laboratory.* Required of Civil Engineering sophomores. Second term. Credit one hour. Courses 221 and 221-A are closely correlated and should be taken concurrently. Experiments designed to illustrate the principles of mechanics studied in Course 221. One $2\frac{1}{2}$-hour period a week. Assistant Professors HOWELL, CUYKENDALL, GIFFT, and Mr. PRIEST.

222. *Advanced Mechanics.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 220 and 221. Following a brief general review of fundamental topics in Mechanics of Materials, this course covers induced stresses; torsion, unsymmetrical bending; torsion of prisms of non-circular section; hoops; flat plates; localized stresses; theory of least work; internal work and its derivatives. Textbook: Seeley, *Advanced Mechanics of Materials.* Recitations, three hours a week. Assistant Professor HOWELL.

223. *Engineering Problems.* Required of Civil Engineering seniors except in the Sanitary, Structural, and Hydraulic Engineering Options. Either term. Credit two hours. Prerequisites, courses 220, 221, and 240. The object of this course is to provide a review involving additional practice in using the principles and methods of applied mechanics. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics, is given out for solution. Computations and reports. Five hours a week. Assistant Professor HOWELL.

224-A. *Engineering Mathematics.* Elective. Seniors and graduates. Required of Civil Engineering seniors in the Structural Engineering Option. First term. Credit three hours. Prerequisite, Mathematics 55b. An elementary course in ordinary differential equations with applications to engineering problems. Trigonometry, calculus, and algebra are dealt with in so far as this is necessary for a clear understanding of the treatment of differential equations. The purpose of this course is to lay the foundation for the more advanced courses in engineering mathematics. Textbook: Phillips, *Differential Equations.* Three recitations a week.

224-B. *Advanced Engineering Mathematics.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, Course 224-A. This course is an introduction to the mathematics used in the solution of advanced engineering problems. Special emphasis is given to partial differentiation. Fourier Series,

line integrals, formation of partial differential equations, integration in form of infinite series of several of the partial differential equations arising in engineering problems, vector notation, conformal representation, determinants, theory of the complex variable, development of function into series, etc., are reviewed in so far as a knowledge of these is essential to the course.

224-C. *Advanced Differential Equations.* Elective for graduates only. First term. Credit three hours. Prerequisite, courses 224-A and 224-B or their equivalents. A systematic study of differential equations. Partial differential equations and their solutions are emphasized. Assistant Professor CUYKENDALL.

224-D. *Special Mathematical Topics.* Elective. Graduates only. Second term. Credit three hours. Prerequisites, courses 224-A and 224-B. The content of this course depends largely on the needs and interests of those enrolled. Generalized coordinates, vector analysis, and the calculus of variations are three subjects to be considered.

228-A, B. *Applied Elasticity.* Elective for graduates. Open to qualified undergraduates. Throughout the year. Credit three hours each term. Three lectures a week. Prerequisites, 224-A, 224-B, or Mathematics 200 or 70. General theorems of the elastic solid, reciprocal theorem, sudden loading. Tension, flexure, and torsion of bars of arbitrary section. Castigliano's theorem with application to frames, rings loaded in and normal to plane, spiral and helical springs. Stress in thick cylinders and discs due to pressure, heating, and rotation. Beams on elastic foundations. Symmetrical deformation of thin tubes. Propagation of stress waves in bars.

In the second term the topics are chosen from: Thermal stress. Stress-analysis, stability, and vibration, of plates and shells. Vibration of beams. Professor GOODIER.

228-C. *Engineering Physics of Metals.* Elective. Primarily for graduate students. Second term. Credit three hours. An introduction to the physical basis of matter in relation to its elastic and plastic behavior. Topics for discussion include atomic basis of generalized Hooke's Law, atomic cohesive forces and potential troughs, the yield value, primary bonds, dipole and Van der Waal's forces, influence of temperature on elastic properties, thermoelastic basis of internal friction, experimental and theoretical strengths of crystals, distortion of the lattice, Smekal's criticism of Born's lattice theory of metals, evidence of submicroscopic structure, elementary concepts of the cooperative phenomena in metals. Assistant Professor CUYKENDALL.

229-A. *Theory of Elastic Stability.* Elective for seniors and graduates. First term. Credit three hours. Prerequisite courses, 220, 221, 224A, or equivalents. Mathematical analysis of the conditions under which columns, beams, rings, tubes, thin plates, and thin curved shells may fail by general or local buckling. Applications to mechanical, civil, naval, and aeronautical structures. Professor GOODIER. (Given only in alternate years. Not given in 1942–43.)

229-B. *Mechanics of Vibration.* Elective for seniors and graduates. First term. Credit three hours. Prerequisite, Course 224A. The characteristic phenomena of mechanical vibrations encountered in engineering, and their quantitative investigation, illustrated by a group of typical vibrating systems. Representation of simple harmonic motion. Combination of several

simultaneous motions. Simple cases of free and forced vibrations, with damping. Resonance. Principles of transmission and isolation of vibration. Systems of variable mass and variable elasticity. Vibrations of taut wires, bars, beams, rings, membranes, and plates. Relation of vibration and noise. Detection and measuring instruments. Examples of diagnosis and preventive measures. Professor GOODIER. (Given only in alternate years. To be given in 1942–43.)

MATERIALS OF CONSTRUCTION

225. *Materials of Construction.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisite Course 221. The materials studied are lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. Three recitations a week. Professor SCOFIELD.

226. *Materials Laboratory.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisite course 221 and must be taken with or preceded by 280. Experimental determination of the properties of materials by mechanical tests. Study of testing machines (their theory, construction, and manipulation); calibration of testing machines and apparatus; commercial tests of iron and steel; tensile, compressive, torsional, shearing, and flexure tests of metal and various woods with stress-strain observations; tests of cement, concrete aggregate, concrete, plain and reinforced, and of road material and paving brick. The course is planned to supplement Course 225 with its study of the properties of materials by the actual handling of the materials and by observations of their behavior under stress. Laboratory work five hours a week. Professor SCOFIELD and Assistant Professor CUYKENDALL.

227. *Testing of Materials.* (*Laboratory.*) Given especially for students in the College of Architecture. Second term. Credit one hour. A brief course in laboratory methods comprising tests of beams and columns in steel, wood, and concrete. Professor SCOFIELD and Assistant Professor CUYKENDALL.

227-A. *Concrete and Concrete Materials.* Elective for seniors and graduates in Mechanical, Chemical, Electrical Engineering. Either term. Credit one hour. A brief course in the study of concrete and the materials entering into concrete. The course will consist of lectures and laboratory work. One 2½-hour period a week. Professor SCOFIELD.

For Research in Engineering Materials, see Course 297b.

HYDRAULIC ENGINEERING

230. *Water Supply.* Required of all Civil Engineering seniors. Either term. Credit three hours. Prerequisite, course 240. About half of the term is devoted to the methods of making the preliminary investigations for a hydraulic development involving the use of a stream; general hydrology; water resources of a basin; methods of systematic stream gaging; stream characteristics; working up data; use of mass curves in storage studies; percolating waters; probably dependable draft, etc. The second half of the term is devoted to a review of the methods of developing public water supplies

from the several sources; typical structures; a study of the working conditions and fundamental data for designing conduits, distributing reservoirs; and a network of street mains; particular attention being given to the requirements for fire protection and the economics of pumped supplies. In the problems, applications of the text are made to particular localities, the topographic maps of cities and drainage basins forming the bases of the problems. Students contemplating extensive election of courses in the hydraulics group should arrange to take this course the first term. Courses 231, 232, and 233 are elaborations of details in this course. Textbooks: Turneaure & Russell, *Public Water Supplies;* Hoyt & Grover, *River Discharge.* Three recitations a week. Professor SEERY.

231. *Hydraulic Construction.* Elective for seniors and graduates and required of Civil Engineering seniors in the Hydraulic Engineering Option. Second term. Credit three hours. This is a computing and designing course dealing with problems of water storage and the design and construction of dams by means of lengthy problems to be solved by graphical and analytical methods, and involving the economics of water storage at a given site; the design of a high masonry dam by Wegmann's Method and the tests for safety and stability of design, and the analysis of stresses and stability. Professor SEERY.

232. *Water Power.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 230 and 240 or the equivalent. The subject matter of the course covers the technique of hydraulic turbines, the analysis of test data, a study of the adaptation of turbine types to working conditions, unsteady flow and surging in long conduits, governing, and the analysis of the power available at a low head millsite. Textbook: Mead's *Water Power Engineering.* Three lectures and recitations a week and the working of three lengthy problems during the term. Professor SEERY.

233. *Hydraulic Engineering.* Elective. Seniors and graduates. First term. Credit three hours. The theory of percolating water; ground water development; recent developments in soil technology and the design and construction of earthen dams and levees; theory of design of gravity and arch masonry dams and distribution of stresses in such structures; spillway design; preparation of dam sites; construction methods and plants. Lectures, recitations, and abstracting of references. Professor SEERY.

234. *Conservancy and Reclamation Problems.* Elective. Seniors and graduates. Second term. Credit three hours. Flood flow estimates; planning for and designing of flood protection structures, irrigation, and drainage works. The Miami Conservancy work will be the chief source of material for the course. Lectures, recitations, and abstracting of references. Professor SEERY.

236. *Water Power and Pumping Plants.* Elective. Seniors and graduates. Second term. Credit three hours. This is a computing and designing course devoted to the problems of designing and detailing power and pumping plants. Prerequisites, courses 230 and 232. Professor SEERY.

(For *Hydraulic Engineering Design,* see course 291c.)

THEORETICAL AND EXPERIMENTAL HYDRAULICS

240. *Hydraulics.* Required of all Civil Engineering juniors. Either term. Credit four hours. Prerequisites, courses 220 and 221. Hydrostatic pressure; manometers; strength of pipes; stability of dams; immersion and flotation;

flow of liquids through orifices, nozzles, Venturi meters, and pipes, and over weirs; time required to empty tanks and reservoirs; simple, compound, branching, and looping pipes; elementary power calculations in common pumping and fire protection problems; flow of water in open channels; pressure on stationary solids due to deviated flow. Elementary consideration of modern water wheels. Textbook: Schoder and Dawson's *Hydraulics*. Three recitations and one laboratory period a week. About ten of the recitation periods are utilized for demonstration lectures. Professor SCHODER.

240-A. *Hydraulics*. For special groups. First term. Credit one hour. This course covers the laboratory work only of course 240. One laboratory period a week. Professor SCHODER.

241. *Advanced Hydraulics*. Elective for seniors and graduates. Second term. Credit three hours. Prerequisite, course 240. Topics selected from the following list are taken up, subject to changes to suit group requirements: stability of flotation; barometric levelling; flow over weirs and dams, free and submerged; backwaters and non-uniform flow in open channels; the hydraulic jump; water hammers; surges in pipes and canals; flow of liquids and gases in pipes, hydraulic similitude and flow in models; some introductory elements of hydrodynamics; impulse wheels and turbines; centrifugal pumps. Lectures, recitations, and problems. Three hours a week. Professor SCHODER.

242. *Hydraulic Measurements*. Elective for seniors and graduates and required for seniors in the Hydraulic Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisite, course 240. Experimental studies involving usually (as time permits) current meters and floats in canal or river; Pitot tubes in pipes; water meters; weirs; the hydraulic jump; special features of orifices, nozzles, Venturi meters, pipes; model studies; such other occasional experimental measurements as opportunity offers in the laboratory or in the neighborhood of Ithaca; the determination of efficiency, capacity, and characteristics of hydraulic machinery by tests. Three periods a week in laboratory or computing room. Professor SCHODER.

(For *Engineering Research in Hydraulics*, see course 297c.)

MUNICIPAL AND SANITARY ENGINEERING

250. *Sanitary Biology*. Required in the Sanitary Engineering Option in Civil Engineering. Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. First term. Credit three hours. The course is designed to familiarize the student with the use of the microscope, preparation of media, bacteriological analyses of water, sewage, sewage effluents, and sewage sludge; the preparation and use of stains; disinfection of sewage and of swimming pools. Textbook: Buchanan's *Bacteriology*. One recitation and two laboratories a week. Professor WALKER.

251. *Sanitary Biology*. Required in the Sanitary Engineer Option in Civil Engineering. Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. Second term. Credit two hours. The subject matter covered in the course includes the collection, identification, and control of the various forms of plant and animal life most prevalent in water supplies, and associated with sewage wastes and industrial waste-polluted streams. Consideration is given to the making of biological counts and to the use of biological forms of life as indices of pollution. Various references

and texts are used in the course. One recitation or lecture and one laboratory a week. Professor WALKER.

252. *Sewerage and Sewage Treatment.* Required of all juniors or seniors in Civil Engineering. Elective for Chemical Engineering students and for others having prerequisite training. Either term. Credit three hours. Prerequisite, course 240. The design of sanitary and of storm sewers, and the methods of treating sewage are considered in the recitations; and in the computing period, problems are assigned dealing with design and operation and with subject matter considered in recitation and class-room work. The problems are largely of the nature of separate designs. Textbook: Metcalf and Eddy's, *Sewerage and Sewage Treatment.* Two recitations and one computing period a week. Professors WALKER and STANLEY and Assistant Professor GIFFT.

253. *Control and Treatment of Water Supplies.* Required in the Sanitary Engineering Option. Elective for other seniors and graduates. Second term. Credit three hours. Prerequisite, course 253A. This course comprises a comprehensive study of the general principles and methods involved in furnishing safe water supplies of satisfactory quality. The topics studied include the character of surface and underground water supplies; inspection of sources; relation of communicable diseases to water supplies; standards of quality and examination procedures to determine quality and safety of supplies; water treatment methods including coagulation, sedimentation, aeration, slow and rapid sand filtration, tastes and odor control, softening and iron removal, corrosion control, sterilization, and miscellaneous treatment methods. Also some study of design and operation of water treatment plants is included. Two recitations and one computation period a week. Professor STANLEY.

253-A. *Treatment of Water.* Required of all juniors or seniors in Civil Engineering. Elective for Chemical Engineers. Second term. Credit two hours. Prerequisite, course 240. This course is designed to be an introductory course dealing with the design and the operation of water treatment plants, consideration being given to filter construction and to the conditions calling for treatment of water for domestic or industrial use. Textbook: Turneaure & Russell, *Public Water Supplies.* One recitation and one inspection, computing, or design period a week. Professors STANLEY and WALKER.

254. *Sewerage Works.* Required in the Sanitary Engineering Option in Civil Engineering. Elective for other seniors and graduates. First term. Credit three hours. Prerequisite, course 252. A comprehenisve study of principles and methods involved in the design, construction, and operation of sewers and sewerage treatment works, including reference to existing typical plants. In general, the study includes the determination of capacity and design of sewers; the disposal of sewage by dilution or broad irrigation; stream pollution and self-purification; sewage treatment methods, including preparatory devices, sedimentation, chemical precipitation, intermittent sand, and trickling filters, activated sludge, sludge digestion, sludge dewatering and incineration, and miscellaneous treatment methods. Textbook: Metcalf and Eddy, *American Sewerage Practice, Vol. III, Disposal of Sewage.* Two recitations and one computation period a week. Professor STANLEY.

255. *Treatment of Wastes.* Required for seniors in the Sanitary Engineering Option in Civil Engineering. Elective for other seniors and graduates in Civil Engineering and for Chemical Engineers. First term. Credit three hours.

Prerequisite, course 252. The treatment of municipal and industrial wastes such as garbage, and the wastes from tanneries, packing-houses, mines, canning factories, textile mills, paper and pulp mills, creameries, cheese factories, condensaries, breweries, sugar refineries, etc. Flow or process charts are used to show the general character of the waste, and methods of treatment applicable are considered. Special attention is given to experimental studies of waste treatment, and to plant-scale treatment. Numerous references, bulletins, reports. Three lectures or recitations a week. Professor WALKER.

256. *Municipal Administrative Engineering.* Required for Civil Engineering seniors in the B.S. in A.E. Course. Elective for other seniors and graduates. First term. Credit three hours. A study of civic government and the relationships between the civil engineer in public service and various city, county, state, federal, and special governmental bodies, with which he may become associated; general principles involved in the operation and administration of the public works department and the effect of these on the activities of the engineer; methods of financing governmental operations, including bond issues, sinking funds, special assessments, service and rental charges. Three lecture or recitation periods a week. Professor STANLEY.

256-A. *Public Health Engineering.* Elective for seniors and graduates. Second term. Credit three hours. A study of the place of the engineer in public health work. Organization and operation of Boards of Health; mosquito abatement, epidemiology and vital statistics, public health laws, and the sanitary code. Three lecture or recitation periods a week. Professor STANLEY.

256-B. *Rural Sanitation.* Elective for juniors, seniors, and graduates. Second term. Credit two hours. A course dealing with the sanitation of rural areas, trailer and other camps, summer hotels, and swimming pools. Attention is given to water supply, sewage and garbage disposal, and to the problem of milk sanitation. Lectures, reports, and recitations. Two periods a week. Professor WALKER.

257A. *Conference on Present Methods of Water Treatment.* Elective for seniors and graduates. Either term. Credit three hours. A critical study of specific problems in water treatment, control of water-sheds, the design, construction, and operation of water treatment plants. Readings, investigations, inspections, and reports. Hours to be arranged. Professor STANLEY.

257B. *Conference on Present Methods of Sewage Treatment.* Elective for Seniors and graduates. Either term. Credit three hours. A critical study of specific problems in sewage disposal, sewage treatment methods, the design, construction, and operation of sewage treatment plants. Readings, investigations, inspections, and reports. Hours to be arranged. Professor STANLEY.

258. *Water and Sewage Analysis.* Required of juniors in the Sanitary Engineering Option in Civil Engineering. Elective for other juniors and seniors. First term. Credit two hours. The purpose of the course is to acquaint the student with the standard procedures followed in making physical and chemical analyses of water and of sewage. Textbooks: Standard Methods of Water Analysis, A.P.H.A., Water and Sewage Analysis, Eldridge, Theroux, and Mallman. Two laboratory periods a week with lectures, recitations, and laboratory work. Professor WALKER.

259. *A Laboratory Course for Graduates.* Hours to be arranged. A course devoted to some problem of water or sewage or trade waste, such as the operation of a water filtration plant, a sewage disposal plant, the detection, measurement, and treatment of trade wastes, the value of disinfection, etc. Professor WALKER.

(For *Sanitary Engineering Design and Research*, see courses 291d and 297d.)

TRANSPORTATION ENGINEERING

260-A. *Location Surveying.* Required of all Civil Engineering students as a part of Summer Survey Camp, following the sophomore year. Credit one hour. Taken concurrently with course 213 (Four hours credit. See description on page 76.) Each section is required to make complete preliminary and location surveys for a line two or three miles long. In this work the section is divided into level, transit, topography, and cross-section parties, as the different phases of the work are encountered. Finally structure and right of way surveys are made. The assignments of the men are changed every day so that each student receives practice in the various kinds of field work. Attendance at summer camp for one week is required. Date of beginning will be announced in the second term. Professor BARNES, Assistant Professors PERRY and THATCHER, and Mr. SPRY.

260-B. *Route Surveying and Drawing.* Required of all Civil Engineering sophomores. Second term. Credit three hours. Prerequisite, Advanced Surveying 211. The recitations cover the theory of simple, transition, and vertical curves, and earthwork computations; with applications to practical problems for purposes of illustration. The field periods take up about two-thirds of the term and are devoted to computing, laying out and checking simple, transition, and vertical curves. Each section is divided into parties of three so that each student obtains more individual instruction, more practice in handling instruments, and a more intimate knowledge of the problems than he would in larger parties. The drawing periods take up the remaining third of the term and in them each student makes a pencil map of a preliminary line surveyed in Course 260-A and prepares a detailed "paper location" report based on these data. A tracing and profile of the final location as run in the field is then required, also a computation of part of the earthwork. Textbooks: Pickels & Wiley, *Route Surveying* and Crandall, *Earthwork Tables*. One recitation and two field or drawing periods a week. Professors BARNES and CONWELL, Assistant Professors CRANDALL, PERRY, and THATCHER.

261. *Railroad Maintenance of Way.* Elective. Seniors and graduates. This course or course 266 is required for seniors in the Transportation Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisite, course 260-B. The subjects treated are track materials (with special reference to the section, method of manufacture, and composition of steel rails, to the economics of tie preservation and the use of metal ties, and to the effect of quality of ballast upon maintenance); machine and other methods of grading for second track; drainage; track laying by both machine and hand methods, ballasting and bringing new track to line and grade; turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards; track maintenance; track tools, work trains; action of car wheels on curves; widening of gage; double tracking; separation of grades; and improvement in grades and alinement. Textbook: Tratman, *Railway Track and Maintenance.*

Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

262. *Railroad Operation and Management.* Elective. Seniors and graduates. This course or course 267 is required of seniors in the Transportation Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 260-B. Under organization, the following subjects are treated: general principles underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yards, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

263. *Route Location.* Required of juniors in the Transportation Engineering Option in Civil Engineering. Elective for seniors and graduates. Second term. Credit three hours. Prerequisites, courses 260-A and 260-B. A detailed study is made of the economic principles and other factors governing the location of new routes for both railroads and highways, and the revision of existing lines to effect the most efficient and satisfactory transportation. Some of the topics treated are estimation of traffic and revenue; costs and rates; steam, electric, and other locomotive and motor operation; gradients, distance, curvature, and rise and fall; line and grade revisions; grade crossing eliminations; location surveys and estimates. Lectures and recitations with problems involving investigations of projects, revisions, and comparisons of alternate routes. Textbook: Williams, *Design of Railway Location.* Three hours a week. Professor BARNES.

264. *Engineering Construction.* Required of all Civil Engineering sophomores. Either term. Credit three hours. A fundamental course designed to acquaint the student with the financial and economic principles underlying human enterprises, both public and private; and with the agencies—money, men, materials, and machines—utilized in carrying out construction projects, and their correlation and control. About one-third of the term is devoted to such topics as the history of engineering and the role of the civil engineer in the progress of civilization, cooperation with other professions, day labor and contract methods of control, types of contracts, elements of cost, including depreciation and overhead, life and economic selection of structures, planning and plant layouts including the plotting and use of the Mass Diagram. The other two-thirds of the term are devoted to the methods and processes of construction with special attention to the equipment available and its adaptability to various kinds of work. Problems and reports on references to periodical literature are required of all students. Lectures and recitations three hours a week. Professors BARNES and CONWELL and Assistant Professors CRANDALL, PERRY, and THATCHER.

265. *Highway Engineering.* Required of all Civil Engineering seniors. Elective for certain graduates. Either term. Credit three hours. Prerequisites, courses 260-A, 260-B and 287. The course consists of lectures and recitations

considering the economic selection of routes, economics of location, modern tendencies in design and practice, subgrade soils, drainage, subgrade stabilization, finance, and the technique of construction and maintenance of flexible and rigid types of pavements. In addition to the class work a problem is assigned which requires a complete redesign for modern traffic conditions of an old highway. Lectures and recitations three hours a week. Professor CONWELL.

265-A. *Low Cost Roads.* Elective. Seniors and graduate students. Either term. Credit three hours. Prerequisite, course 265 or its equivalent. Study of economic importance of routes and selection of farm to market roads to be improved; location and design; subgrade soils and stabilization of subgrade soils by use of admixtures, chemicals, and bituminous materials; drainage and drainage structures; bituminous treatments and bituminous mats for stabilized subgrades. Survey of the experimental work in the use of materials and design and construction of low cost roads. Design, construction, and maintenance of road mixes, plant mixes, etc. Professor CONWELL.

266. *Highway Laboratory.* Elective. Seniors and graduates. This course or course 261 is required of seniors in the Transportation Engineering Option in Civil Engineering. Either term. Credit three hours. Prerequisite, course 265 or may be taken concurrently with course 265. Non-bituminous and bituminous materials are tested. Subgrade soils are sampled and their properties examined; subgrade stabilization admixtures are also tested and studied. Bituminous mixtures are designed and their properties examined. Professor CONWELL.

266-A. *Advanced Highway Laboratory.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 265 and 266. Non-bituminous and bituminous materials are tested and their characteristics studied. Soils are sampled and examined, and investigations made of the behavior of mixtures of soils with bituminous and non-bituminous materials. Special investigations and tests are made to determine the properties of various combinations of materials and the effects of modifications in design. Two laboratory periods a week. Professor CONWELL.

267. *Advanced Highway Engineering.* Elective. Seniors and graduates. This course or course 262 is required of seniors in the Transportation Engineering Option in Civil Engineering. Second term. Credit three hours. The topics for assignment and discussion include the economics of highway engineering, highway finance, legislation, regulation, traffic, design, construction, and maintenance of highways, the latest research programs and reports, labor and plant organization for various kinds of highway contracts with especial emphasis on the economics of contracting, etc. This course is conducted as a seminar. Meetings are held once each week at hours to be arranged. Professor CONWELL.

268. *Modern Highway Planning and Design.* Elective. Seniors and graduate students. Second term. Credit three hours. Prerequisite, course 265 or its equivalent. Study of geographical, political, and economic divisions of communities with particular reference to highway transportation requirements; analysis of regional plans chiefly concerning the classification of roads and the selection of routes to be abandoned or improved, based upon their economic justification. Design of regional systems of highways, freeways, and

parkways, including the consideration of the economic, safety, and aesthetic aspects. Traffic studies, legislation, financing, and zoning. Design of intersections and grade separations. Problems and reports required. Professors CLARKE and CONWELL.

269. *Transportation.* Required of seniors in the Transportation Engineering Option and the B.S. in A.E. Course in Civil Engineering and may be elected by other qualified seniors and graduates. Second term. Credit three hours. A course covering travel and transport agencies with special reference to their facilities, ownership, financing, regulation, and coordination. A brief review of the development of transportation throughout the world is used as a background for an intensive study of the present situation in the various countries and comparison of the policies and practices in use. Particular attention is given to the various proposals designed to promote more efficient use of the various transportation agencies in the United States by better coordination, pooling of facilities, etc., and economic studies are made of some of the new projects which are under discussion. Professor BARNES.

(For *Railroad and Highway Engineering Design and Research*, see Courses 291e, 291g, 297e, 297g.)

STRUCTURAL ENGINEERING

270. *Stress Analysis and Structural Design.* Required of all juniors in Civil Engineering. Either term. Credit four hours. Prerequisites, course 220 and 221.

Stress Analysis. Graphic analysis of simple and cantilever beams, roof trusses, and framed bents. Determination of position of moving concentrated loads for maximum shears and moments in beams and deck girders; also for through girders and maximum floor beam reactions for same. Stresses due to dead load, live load, impact, and wind load in the principal types of simple trusses employed in modern construction. Stiff web systems and counter bracing. Three-hinged roof and bridge arches. Practical problems in actual stress computation throughout the course. Textbook: Urquhart and O'Rourke's *Stresses in Simple Structures.* Three recitations a week.

Structural Design. Graphic analysis of stresses in a timber truss. Design of truss members and joint details. Computations, systematically arranged in the form of reports, and working drawings. Textbook: Jacoby and Davis's *Timber Design and Construction.* Computation and drawing, two and one-half hours a week. Professors URQUHART and O'ROURKE, Associate Professor BURROWS and Assistant Professor PENDLETON.

270-A. Required of Army graduate students who are candidates for the M.S. in Engineering degree. Credit three hours. A course based on the content of course 270. Two recitations and one design period a week. Professor MALCOLM.

271. *Structural Design.* Required of all juniors or seniors in Civil Engineering. Either term. Credit three hours. Prerequisite, course 270 or 270-A. An elementary course in steel design. Principles of both riveted and welded connections. Complete designs and detail drawings of the steel skeleton of a small building, including trusses, and of a through plate girder bridge. Textbook: Urquhart and O'Rourke's *Design of Steel Structures.* Three computation or drawing periods a week. Professors URQUHART and O'ROURKE, and

Associate Professor BURROWS, and Assistant Professors PENDLETON and GIFFT.

272. *Advanced Structural Analysis.* Elective for seniors and graduates and required of seniors in the Structural Engineering Option in Civil Engineering and of all graduate students majoring or minoring in structural engineering. Either term. Credit three hours. Prerequisite, course 270. Stress analysis of continuous beams, framed bents, and rigid frames. Horizontal as well as vertical loading considered. Redundant structures including the braced two-hinged arch. Displacement diagrams for trusses and arches and analytical computation of deflections of such structures. Three recitations a week. Professors URQUHART and O'ROURKE.

273. *Steel Buildings.* Elective. Seniors and graduates. First term. Credit three hours. Prerequisites, courses 220, 221, and 271. This course comprises the design of the steel framework for buildings of the prevailing type used in power house or shop construction. Dead, snow, and wind stress diagrams are drawn for the roof trusses. Provision is made for an electric crane moving the full length of the building and the stresses in the framework due to the movement of the crane are determined. The effect of the wind and the eccentric load due to the crane girder are considered in the design of the columns. Textbook: Ketchum's *Steel Mill Buildings.* Reports and drawings. Three two-hour periods a week. Associate Professor BURROWS.

274. *Bridge Design.* Elective. Seniors and graduates. This course or course 284 is required for seniors in the Structural Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 271. Computations and drawings for the complete design of a railroad bridge of six or seven panels or a heavy highway bridge. The computations to determine the stresses and sections of all members, pins, pinplates, splices, deflection, camber, and other details as well as of connecting rivets are to be written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Textbook: Johnson, Bryan & Turneaure, *Modern Framed Structures, Vol. III.* Computation and drawing, three two-hour periods a week. Associate Professor BURROWS.

275. *Investigation of Existing Bridges.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, course 271. Inspection of existing structures for the determination of sizes and conditions of plates and shapes. After full data have been obtained in the field, computations will be made to determine either the unit stresses under a specified load, or the safe load or rating according to standard specifications. Hours as assigned. Associate Professor BURROWS.

279. *Elements of Structural Engineering.* Elective. Seniors in Electrical Engineering. Second term. Credit two hours. Analysis and design of beams of steel, timber and concrete, columns, footings, and retaining walls. Textbook: Urquhart & O'Rourke's *Elementary Structural Engineering.* One lecture and one computing period a week. Professor URQUHART.

280. *Concrete Construction.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisites, courses 220 and 221. (Preferably taken

concurrently with or preceded by course 225.) Properties of plain concrete, elementary theory of reinforced concrete as applied to rectangular beams, slabs, T-beams, beams reinforced for compression, columns, and footings. Shear, diagonal tension, and direct stress combined with flexure. Computations in the forms of reports on the design of a typical beam and girder floor panel and of a retaining wall. Detail sketches of sections and reinforcement required. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Six hours a week. Professors URQUHART and O'ROURKE and Assistant Professor PENDLETON.

280A. *Concrete Construction*. For architects. First term. Prerequisites, Arch. 210 and 211, or C.E. 220 and 221. (Students who have taken C.E. 220 and 221 may substitute 280 for 280A.) Credit three hours. Properties of plain concrete, elementary theory of reinforced concrete as applied to beams and slabs, columns, footings, and retaining walls. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Three two-hour periods a week. Professors URQUHART and O'ROURKE and Assistant Professors PENDLETON and GIFFT.

281. *Foundations*. Required of all Civil Engineering juniors or seniors except in the B.S. in A.E. Course. Either term. Credit three hours. Prerequisites, courses 220 and 221. Piles and pile driving, including timber, concrete, tubular and sheet piles; cofferdams; box and open caissons; pneumatic caissons for bridges and buildings, caisson sinking, and physiological effects of compressed air; pier foundations in open wells; freezing process; hydraulic caissons; ordinary bridge piers; cylinders and pivot-piers; bridge abutments; spread footings for building foundations; underpinning buildings; subterranean explorations; unit loads. Textbook: Jacoby and Davis's *Foundations of Bridges and Buildings*. Recitations, collateral reading in engineering periodicals, and illustrated reports. Three hours a week. Professors URQUHART and O'ROURKE.

282. *Reinforced Concrete Building Design*. Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite, course 280. Design of a reinforced concrete flat-slab building and investigation of various other types of floor systems for commercial buildings. Complete detail design for one building, including stairway, elevator shafts, penthouses, etc. Working drawings and steel schedules. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Seven and one-half hours a week. Professors URQUHART and O'ROURKE.

283. *Fixed Arches*. Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisites, courses 270, 271, and 280. Theory of the curved beam; the closed ring; the fixed arch. Influence lines for arches of various forms. Selection of curvature of axis for various loadings. Effect of temperature and rib-shortening. Effect of plastic flow on stresses in a reinforced concrete arch. Design of a reinforced arch and its abutments. Lectures, recitations, and computations. Six hours a week. Professors URQUHART and O'ROURKE.

284. *Highway Bridges*. Elective. Seniors and graduates. This course or course 274 is required for seniors in the Structural Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 280. Design of short span bridges and their abutments. Comparison of the econ-

omy of steel and reinforced concrete superstructures for bridges of this type. Reports and drawings. Professor O'ROURKE.

285. *Reinforced Concrete Design.* Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. Either term. Credit three hours. Prerequisite, course 280. Design of footings: single and multiple columns of reinforced concrete, I-beam grillages. Design of bins and tanks, subsurface and supported on towers. Design of a highway bridge. Reports and sketches. Three two-hour periods a week. Professors URQUHART and O'ROURKE.

286. *Elastic Foundations and Thin Structural Shells.* Elective. Primarily for graduate students. First term. Credit three hours. Study of the properties of elastic foundations and the application of the elastic foundation theory to the analysis of large diameter, low head tanks, hemispherical domes, hemispherical leaders on large pipes, and thin shell pipes under flexure. Three hours a week.

287. *Soil Mechanics.* Required of juniors in the Regular Four-Year Course and the Sanitary, Structural, Hydraulic, and Transportation Engineering Options in Civil Engineering. Either term. Credit three hours. A comprehensive study of the properties of soil, presenting a conception of its behavior as an engineering material. Theory of soil classification, soil structure, pressure distribution, compressibility, cohesion, elasticity, plasticity, and permeability. Laboratory tests for identification of soils; mechanical analysis, determination of water content, specific gravity, density, permeability, etc. Tests for physical properties of soils. Two lectures and one laboratory period a week. Professors O'ROURKE and Assistant Professor PENDLETON.

288. *Applied Soil Mechanics.* Elective for seniors and graduate students. Second term. Credit three hours. Prerequisite, course 287. Advanced application of soil mechanics, based on the principles and physical studies of course 287. The plastic flow theory; the consolidation theory; stability of earth slopes; flow of water through earth structures; theories of earth pressure on retaining walls, caissons, and tunnels. Review of modern soil mechanics research. Mr. HOUGH.

(For *Structural Engineering Design and Research*, see Courses 291a, 291f, and 297f.)

ADMINISTRATIVE ENGINEERING

290. *Engineering Law.* Required of all Civil Engineering seniors. Juniors admitted only by special permission. Also open to seniors in Architecture, Mechanical, Chemical, and Electrical Engineering, and other seniors submitting acceptable qualifications. Either term. Credit three hours. Essentials of contracts and contract principles; agency, tort, and independent contractor; use and conveyance of lands and waters, including irrigation law, real estate documents, boundary lines, eminent domain and title searches; corporations, partnerships and other contracts of association; sales and transportation contracts; negotiable instruments; bankruptcy, mechanics liens, patents, trademarks, copyrights, courts, wills, and laws of insurance. The course culminates with the preparation of a set of contract documents for an assigned construction job, including advertisement, bond, form of proposal, information to bidders, agreement form, specifications, and general conditions with clauses covering payments, time limit, arbitration, extras, liqui-

dated damages, and abandonment of contract. Tucker's *Contracts in Engineering* is used as a text, supplemented liberally from other sources. Lectures and recitations three hours a week. Professor BARNES, Assistant Professors CRANDALL, PERRY, and THATCHER.

290-A. *Advanced Engineering Law.* Required of seniors in B.S. in A.E. Course in Civil Engineering and open to others who have completed course 290. Second term. Credit three hours. Some of the topics treated in course 290 are here enlarged upon and extended, particularly laws relating to the various phases of construction contracts, employer-employee relationship, workman's compensation, mechanics liens, patents, copyrights, trademarks, and insurance. Among other subjects covered are suretyship, conditional sales, bailments, trusteeship, and taxation. Actual cases are used for illustrating the above and reference is also made to recent court decisions regarding engineering matters. Lectures and recitations three hours a week. Textbook: Simpson & Dillavou's *Law for Engineers and Architects*. Professor BARNES and Assistant Professors CRANDALL, PERRY, and THATCHER.

293. *Engineering Management.* Required of juniors in the Regular Four-Year Course and the Transportation and Geodetic Engineering Options in Civil Engineering. Also open to qualified juniors and seniors in other courses. Either term. Credit three hours. This course is devoted mainly to the management of construction work but also treats briefly of such larger problems as economics of plant location and economic selection of plant, or structure, to fulfill a given purpose. Management is treated under its two main heads—planning and operation. Under planning are such subjects as the selection of methods of procedure which will result in maximum economy, the planning of a thoroughly coordinated organization of men and machines to carry out these methods, and the scheduling and estimating of the work in accordance with the adopted plans. Under operation are selecting, training, and maintaining labor forces including pay systems, accident prevention, welfare work, etc., purchasing, operation, and maintenance of equipment, and keeping the records essential to the management for comparing results with schedules, i.e., cost keeping. Bookkeeping is recognized also as an essential tool of management and the fundamentals of double entry bookkeeping are given, together with the use of control accounts, financial statements, and budgets. Blanks and forms for cost keeping for actual or assumed jobs are required and each student also works out problems in bookkeeping. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor CRANDALL.

293-A. *Engineering Management.* Required of juniors in the Administrative Engineering Option and the B.S. in A.E. Course in Civil Engineering. Second term. Credit three hours. Prerequisite, an elementary course in accounting. Covers the same ground as course 293 except that bookkeeping is omitted and more attention is given to management proper, especially to personnel and labor relations. Cost accounting on engineering construction work is included. Three hours a week. Professor BARNES.

295. *Valuation Engineering.* Elective for seniors and graduates and required for seniors in the B.S. in A.E. Course in Civil Engineering. Second term. Credit three hours. Prerequisite, course 264 and 290 or taken concurrently with 290. Theory and practice of valuation or appraisal for purposes of utility rate making, purchase or sale, eminent domain or condemnation cases, merg-

ers or joint ownership, taxation and assessment, issuance of securities, bank loans, insurance, uniform system of accounting, and improved management. Topics considered include scientific systems of real estate assessment, federal railroad valuation, rate disputes, court rulings, compution of actual rates for gas, telephone, electrical supply and street railways, valuation of land, mines, water power, factories, railroads, toll bridges, buildings, and all kinds of property both tangible and intangible. Detailed examples of forms and methods with outline of typical valuation reports. Lectures, recitations, and reports. Textbook: Marston and Agg's *Valuation Engineering*.

REGIONAL AND CITY PLANNING

(By cooperation of the College of Architecture)

710. *Principles of Regional and City Planning*. Elective. Registration limited to 50. Open to graduates and upperclassmen in all colleges of the University. First term. Credit three hours. The history of the planning of communities, including provisions for housing from ancient times to the present. A review of the basic influences in the development of cities. A general view of the theory and accepted practice of city and regional planning including a study of the social, economic, and legal phases. Occasional lectures may be given by members of other faculties and by outside lecturers selected because of their special experience and skill in certain phases of planning. Lectures, assigned reading, and examinations. M W F 12. *White 201*. Professor CLARKE and Assistant Professor MACKESEY.

711. *City Planning Practice*. Elective. Second term. Credit three hours. Prerequisite, course 710. The procedures and techniques of gathering and analyzing data for municipal planning studies. The selection and integration of data for use in planning. Practical application of the theories of city planning. Office practice. Lectures, assigned reading, reports. M W F 12. *White 201*. Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

712. *Regional Planning Practice*. Elective. Open to graduates and upperclassmen in all colleges of the University. Second term. Credit three hours. Prerequisite Course 710. A study of the principles involved in county, regional, state, and national planning. Includes discussion of following factors involved: land use, water resources, recreation, transportation, public services, and public works. Occasional lectures will be given by members of other faculties and outside lecturers. Lectures, assigned reading, reports, and examinations. Hours to be arranged. Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

713. *Housing*. Elective. Registration limited. First term. Credit two hours. Prerequisite course 710. An introduction to the theory and standards of housing practice through analysis and comparison of various existing examples, considering the social, economic, and technical sides of the work. Students in the College of Architecture will take one or more design programs having some phases of housing as subject. These programs will be substituted for a regular problem in courses 113 or 151 and values, as earned, will be awarded in those courses. Lectures, assigned reading, and reports. Hours to be arranged. *White 201*. Professor CLARKE, and Assistant Professor MACKESEY of the College of Architecture.

714. *Seminar in Regional and City Planning.* Elective. Throughout the year. Credit one hour each term. This course should accompany or follow course 710. Registration limited. Open to students in all colleges of the University, by permission. Investigation of assigned topics on particular aspects of the subject with emphasis on either urban or regional planning. Hours to be arranged. *White, Architectural Seminar Room.* Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

715. *Seminar in Park Planning.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering and others by special permission. First term. Credit two hours. Specific problems relating to the design of city, state, and national parks with a study of examples. T 8–10. *White B-15.* Professor CLARKE. (Not given in 1942–43.)

716. *Seminar in Parkway, Freeway, and Highway Planning.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering. Second term. Credit two hours. Specific problems relating to the design of the modern parkway, freeway, and highway with a study of examples. T 8–10. *White B-15.* Professor CLARKE.

717. *Zoning Principles and Practice.* Open to graduates and upperclassmen in all colleges of the University. Second term. Credit two hours. Prerequisite, course 710. Technical and legal aspects of drafting and administering zoning regulations. Hours to be arranged. Assistant Professor MACKESEY.

GENERAL COURSES

291. *Engineering Design.* Elective. Seniors. Credit three or more hours. The student may make complete designs in one of the following sub-divisions, subject to approval. Hours to be arranged.

(a) *General Civil Engineering.* Either term. Problems in practical design may be taken in any department, the work to be supervised by the department concerned in cooperation with the Department of Structural Engineering in regard to structural features.

(c) *Hydraulic Engineering.* Second term. Prerequisite course 240. For best results Hydraulic Engineering Design should be preceded by Course 230, but the two may be taken concurrently. The purpose of the course is to go more into detail in selected phases of hydraulic engineering and is not to duplicate in large part work regularly given in the scheduled courses in hydraulic and structural engineering. Professor SEERY.

(d) *Sanitary Engineering.* Either term. Credit three hours. This course should be preceded by Courses 252 and 253-A or equivalent courses. The purpose of the course is to teach methods of determining the capacity, basis of design, computations, sketches, and general plans and profiles involved in the design of sewerage, trade waste, and water treatment works. Problems may be elected such as the design of a separate or combined sewerage system, an intercepting sewer, a municipal or an institutional sewage treatment plant, a plant for the treatment or disposal of an industrial waste, or a plant for the treatment of an industrial, institutional, or municipal water supply. Professors STANLEY and WALKER.

(e) *Railroad Engineering.* Either term. The problems are those encountered in the location and construction of railroads, and include the following sub-

jects: Economic location of railroads; culverts; bridges; retaining walls; tunnel and subway design; small depot buildings; freight houses; water supply and coaling plants; icing stations; turntables and engine-houses; gravel washing plants; track layouts with details of signals and interlocking; yard and terminal design, etc. Bills of material and estimates of cost are usually required. The field is so broad that the interest of the student is given consideration in assigning problems. Professor BARNES and Assistant Professor PERRY.

(f) *Structural Engineering.* Either term. Prerequisite, courses 270, 271, and 280. The student may select a problem such as the following: (a) an arch bridge of steel, (b) a cantilever bridge, (c) a rigid frame bridge, (d) a special problem in steel or concrete building design, (e) the design of any other structure of particular interest to the student provided he has had the proper preparation for such design. The work is submitted in the form of reports. Drawings of typical details must accompany reports. Professors URQUHART and O'ROURKE and Associate Professor BURROWS.

(g) *Highway Engineering.* Either term. The problems are those encountered in the selection, location, design, and construction of highways. They include the following: Economic selection of routes, economic location, design of highways, highway intersections, culverts, highway bridges, retaining walls, and other highway structures. Bills of materials and estimates of cost are usually required, also plant layouts and methods of executing work. Professor CONWELL.

297. *Engineering Research.* Elective. Seniors and graduates. Credit three or more hours. Research may be taken in one of the following subdivisions or two or more departments may cooperate in the assignment of special problems. Hours to be arranged.

(a) *Geodetic Astronomy.* Second term. Prerequisites, courses 186 and 216. Investigations of instrumental errors; variation of latitude and azimuth; any and all questions relating to work of the highest precision connected with astronomical problems and geodetic operations. The field is so broad that the interest of the student is given consideration as to the actual research undertaken. Professor BOOTHROYD.

(b) *Engineering Materials.* Either or both terms. Credit one hour for forty hours of actual work. A project may be started during the junior year for completion in the senior year. Prerequisites, courses 225 and 226 or their equivalents. Special investigations of an advanced nature of the properties of structural units and the materials of construction. The aim of the course is to secure results by proper investigational methods which are of the caliber and scope deemed essential for publication. Professor SCOFIELD.

(c) *Hydraulics.* Either term. Prerequisite, course 240 or its equivalent. The subject and scope of the investigations in experimental or theoretical hydraulics should be selected by conference at the beginning of the term if not previously arranged. It is often desirable and is permissible for two students to work together on the same investigation. Written reports are required but the text need not be typewritten in thesis style. These reports are kept by the department. In most cases it is necessary to arrange a definite schedule for work in the laboratory to avoid conflicts. Professor SCHODER.

(d) *Sanitary Engineering.* Either term. Prerequisites for work in this field will depend upon the particular problem to be pursued, but in general will

include work in water analysis, bacteriology, and courses in Hydraulics and Sanitary Engineering dealing with the field in which the work is to be undertaken. Hours, credit for work, prerequisites and other questions relating to contemplated research in this field will be arranged by conference. Professors WALKER and STANLEY.

(e) *Railroad Engineering.* Either term. Special problems in the economics of location, construction, maintenance and operation of railroads, comparison of transportation agencies, traffic studies, and economics of various systems of transport. Professor BARNES.

(f) *Structural Engineering.* Second term. Students wishing to pursue one particular branch of bridge engineering further than can be done in any of the regular courses may elect work in this field. The prerequisite courses depend upon the nature of the work desired. The work may be in the nature of an investigation of existing types of construction or theoretical work with a view to simplifying present methods of design or proposing new methods. Professor URQUHART.

(g) *Highway Engineering.* Either term. Prerequisites, courses 265 and 266. Studies of traffic and traffic regulation and legislation may be made. The field of economics of highway engineering offers a wide variety of problems. Laboratory investigations of subgrade soil, subgrade stabilization, and the effects of modifications in design of bituminous and non-bituminous mixtures provide a wide range of topics for research. Professor CONWELL.

(h) *Management Engineering.* Either term. Special problems relating to the economic, legal, and financial aspects of engineering construction projects, management of public works and appraisals. Professor BARNES.

(i) *Geodetic Engineering.* Either term. Prerequisites will depend upon the line of work to be pursued. Special problems in least squares, reduction of triangulation, and photographic surveying as may be arranged. Professor UNDERWOOD.

298. *Thesis.* Elective. Seniors. Either or both terms. Credit three or more hours. The thesis gives the student, desiring to work out a special problem or make an engineering investigation, and to record the result of his work, the opportunity of so doing. Registration for thesis must be approved by the professor in charge at the beginning of the semester during which the work is to be done.

SPECIAL AND GRADUATE COURSES

All the elective courses are suitable for graduate and advanced students, and may be taken by them in the regular classes. Other special courses will be arranged to suit the requirements of graduate students. These special courses are intended to be pursued under the immediate direction of the professor in charge, the student usually being free from the restriction of the classroom, and working either independently or in conjunction with others taking the same course.

Sibley School of Mechanical Engineering

THE COURSES OF STUDY

The regular four-year curricula offered in this school lead either to the degree of Bachelor of Mechanical Engineering or Bachelor of Science in Administrative Engineering. By attending five years the student may obtain one of these degrees with the benefit of one year's additional work in other studies, generally in the College of Arts and Sciences, thereby broadening his education (see page 110). Also in five years the student may obtain two engineering degrees, the B.M.E. and B.S. in A.E. (see page 113), or the B.M.E. and B.E.E. (see pages 112 and 142). In six years the degrees of A.B. and B.M.E., or of A.B. and B.S. in A.E. may be secured (see page 114). Each of the possibilities is presented in greater detail in the following discussion. Students who can afford the additional time and expense are urged to pursue one of these longer and broader programs.

For the professional degree of M.E. see page 13.

FOUR-YEAR COURSE (B.M.E.)

The four-year course of study leading to the degree of Bachelor of Mechanical Engineering, which the Sibley School of Mechanical Engineering offers, contains the courses of instruction in mathematics, physics, chemistry, mechanics, materials, drafting, materials processing, kinematics and machine design, heat-power engineering, electrical engineering, experimental engineering, economics, and industrial organization and management, that are considered essential to the basic training for this degree. Provision is made in the later years of the course for specialization in any one of several recognized fields of mechanical engineering, for the student who may develop a special interest in one of those fields. That specialization is strictly limited in extent, however, and is not permitted to encroach upon the mastering of fundamentals, which is considered of primary importance. Therefore credit for any such special work may not exceed from eight to twelve hours.

FIRST AND SECOND YEARS

The schedule for the first two years of instruction is the same for all candidates for the degree of Bachelor of Mechanical Engineering. The freshman

program is the same as that for candidates for the degree Bachelor of Science in Administrative Engineering offered in this school (see below), and it differs but little from that for the first-year students in the School of Electrical Engineering (see below); hence a change of candidacy from one degree to another within these schools may be accomplished without complication if effected before starting the second year. As the freshman programs in Civil and Chemical Engineering differ somewhat from that in Mechanical Engineering, a student transferring from one of these schools to this one will not be able to obtain the B.M.E. degree at the end of the fourth year unless he makes the change prior to the second year and makes up the program differences by receiving instruction during one or more summers.

The schedule for the first two years follows:

		HOURS	
		First Term	*Second Term*
FIRST YEAR 37 HOURS	Analytic Geometry and Calculus 55a, 55b	5	5
	General Physics 11, 12	4	4
	General Chemistry 102 or 104	3	3
	Drawing and Descriptive Geometry 3C11	3	0
	Mechanical Drafting 3C12	0	3
	Elementary Surveying 210A	0 or 1	1 or 0
	Metal Working 3S11	0 or 1	1 or 0
	Casting Processes 3S15	2 or 0	0 or 2
	Introductory Lectures 3G11	1	0
	Hygiene 1, 2	1	1
	Total number of hours a term	19	18

In addition to taking the above courses all Freshmen must satisfy the University's requirement of three hours a week throughout the year in Military Science and Tactics. (See the *General Information Number.*)

SECOND YEAR 38 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Strength of Materials 3M22b	0	2
	Physics 21, 22	3	3
	Kinematics, Recitations 3D21	2	0
	Kinematics, Drawing 3D23	2	0
	Kinematics, Recitations and Drawing 3D24	0	3
	Materials of Engineering 3X21, 3X22	3	3
	Machine Tool Processes 3S23	0 or 2	2 or 0
	Measuring Instruments 3S24	0 or 1	1 or 0
	Applied Mathematics 3M24	0	3
	Industrial Organization and Management 3A25a	3 or 0	0 or 3
	Total number of hours a term	18	20

In addition to these courses, sophomores are required to take Military Training.

OPTIONS The several varieties of specialization are provided in upper-class programs, which are designated as options. In all but three of the options, the special work is limited wholly

to the senior year. In the three exceptions—Aeronautical Engineering (Option E), Engineering Mechanics (Option F), Metallurgical Engineering (Option G)—the specialization begins in the Junior year; therefore, a student who is to take one of these options must make his decision before the beginning of that year. The specialized courses peculiar to each option are printed in italics.

Option A. Power-Plant Engineering

The object of the special courses in this option is to acquaint the student with load-curves and their characteristics, station factors, power-plant economics, and the cost of plants and of their component parts and output; the principles of the economic selection and operation of the power-plant machinery with respect to character of the loading, the cost factors, and the local conditions involved; the design of steam power plant equipment with regard to these considerations and the structural requirements; plant location and layout; and similar topics. The special work in this option is confined to the senior year and is taught by lectures supplemented by a computing and layout course.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Elective (See suggested list on p. 116)	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	3 or 0	0 or 3
	Steam and Oil-Engine Power Plants, Lectures 3P44, 3P45	2	2
	Computing and Design 3P46, 3P47	2	2
	Power Plant Economics 3P50	2	0
	Non-resident Lectures 3G41	0	1
	Elective (See suggested list on p. 116)	0 or 5	5 or 0
	Total number of hours a term	18 or 20	19 or 17

Grand total for the Four-Year Course.....150 hours

Option B. Heat Engineering

(Fluid Flow, Heat Transmission, Refrigeration, and Air Conditioning)

The purpose of the special work in this option is to train men in the fundamentals required in solving problems encountered in the rapidly expanding fields of air conditioning, refrigeration, and the industrial utilization of heat. Extended instruction in the basic principles of fluid flow, heat transfer, properties of mixtures, and refrigeration are given during the first term of the senior year. In the second term important applications of these principles of air conditioning for the purpose of improving human comfort and for the control of the properties of hygroscopic materials during manufacturing processes are given.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Elective (see suggested list on p. 116)	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heat Engineering 3P57, 3P58	4	4
	Refrigeration 3P49	2	0
	Non-resident Lectures 3G41	0	1
	Electives (see suggested list on page 116)	4	4
	Total number of hours a term	19	18

Grand total for the Four-Year Course.....150 hours

Option C. Industrial Engineering

This option is intended for those who wish to enter the commercial side of engineering or who are particularly interested in industrial organization and administration. In the special senior courses in this option, the following topics are discussed: modern time-keeping and cost finding systems; wage payment plans; methods of planning work and insuring production, such a materials handling, machine rate, production control, stores ledgers, quality and quantity control, equipment selection, factory location, and factory planning; also time and motion studies, process charts, engineering economy problems, labor relations, and similar subjects. In the laboratory courses, the graphical work includes the application of these fundamental principles to planning industrial enterprises. Students expecting to elect this option are advised to read for preparation as much industrial history and kindred subjects as possible.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Elective (see suggested list on page 116) Motion and Time Study 3I54 recommended	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	3	0
	Industrial Engineering 3I43, 3I44	3	3
	Industrial Relations 3A49	2	0
	Principles of Cost Control 3A47	0	3
	Industrial Engineering Economy 3I48	0	2
	Non-resident Lectures 3G41	0	1
	Electives (see page 116) Motion and Time Study 3I54 recommended if not already passed	2	0
	Total number of hours a term	19	18

Grand total for the Four-Year Course ..... 150 hours

Option D. Automotive Engineering

The specialization in this option is confined to the senior year and begins in the first term with the study of the broad purposes of the automotive vehicle taken as a whole; the main functions, steering, driving, braking, suspension; power for operation; power transmission; the specific structures and their detailed actions. The second term deals with the power plant theory, design, and operation; nature of working fluid; preparation for and control of combustion; power conversion; efficiencies and mechanism of the engine. There are two lectures and two computing periods a week. The latter are usually devoted to analytical work, but sometimes to drawing, laboratory, or demonstration.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Elective (see suggested list on page 116)	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	3 or 0	0 or 3
	Automotive Lectures 3B41, 3B42	2	2
	Automotive Design 3B43, 3B44	2	2
	Non-resident Lectures 3G41	0	1
	Electives (see suggested list on page 116)	3 or 5	4 or 2
	Total number of hours a term	19 or 18	18 or 19
	Grand total for the Four-Year Course		150 hours

Option E. Aeronautical Engineering

Students who are interested in aeronautical work may find a limited amount of specialization in aeronautics desirable in the senior year. For this option, the student must have elected an introductory course in aerodynamics in the junior year, and should preferably have had some instruction in practical flying. Flight training is not offered by the University, but can be obtained at the Ithaca Airport, within two miles of the Cornell campus. The student is introduced to practical engineering work by problems in the design and construction of airplanes. The study of aeronautic power plants is undertaken with the automotive group.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Aerodynamics 3B35	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	0	3
	Automotive Power 3B42	0	2
	Internal Combustion Engines 3P52	2	0
	Airplane Design Recitations 3B46	2	0
	Airplane Design Computations 3B47, 3B48	2	2
	Non-resident Lectures 3G41	0	1
	Electives (see suggested list on page 116)	3	2
	Total number of hours a term	18	19

Grand total for the Four-Year Course.....150 hours

Option F. Engineering Mechanics

The special courses of this option introduce the student to the analysis of problems of stress, elastic stability, vibrations, and fluid motions, especially as they occur in engineering investigations. The work calls for a fair degree of mathematical aptitude.

		HOURS *First Term*	HOURS *Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 or 39 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Aerodynamics 3B35, 2 hrs. or *Advanced Engineering Mathematics*, CE224, 3 hrs.	0	2 or 3
	Total number of hours a term	20	18 or 19
FOURTH YEAR 36 or 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	0	3
	Applied Elasticity 3M56, 3M57	3	3
	**Mechanics of Vibration* 3M58 or	3	0
	**Theory of Elastic Stability* 3M60	3	0
	Advanced Fluid Mechanics 3M61	0	3
	Non-resident Lectures 3G41	0	1
	Electives (see list on page 116)	3 or 2	0
	Total number of hours a term	18 or 17	19
	Grand total for the Four-Year Course		150 hours

*These courses are given alternately, one each year.

Option G. Metallurgical Engineering

This option of studies does not represent a complete curriculum in Metallurgy, because that would require a much wider specialization in Physical Chemistry, Metallography, and Metallurgy than is here included. The option is intended to give students who are interested in the metallurgical field, mainly iron and steel, some training which will enable them to get a start along this line.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Introductory Metallography, Chem. Eng. 545	3	0
	Electives (see suggested list on page 116)	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	0	3
	Economic Organization 3A21	3	0
	Applied Metallography 3X52	2	0
	Advanced Metallography, Chem. Eng. 550	0	3
	Metallurgical Electives	3	3
	Non-resident Lectures 3G41	0	1
	Electives (see suggested list on page 116)	1	0
	Total number of hours a term	18	19

Grand total for the Four-Year Course.....150 hours

Option H. Mechanical Engineering Design

The purpose of this option is to make available in the senior year further work in mechanical engineering design to those interested. The specialization includes dynamics and vibrations of machinery and photoelasticity in the first term and includes in the second term, advanced problems in stress analysis of machine and structural members and welding applied to machine design or the design of thin and thick pressure vessels, heads, flanges, and attachments.

		HOURS	
		First Term	*Second Term*
FIRST TWO YEARS	See page 98.		
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	E. E. Theory 415, 416	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Mechanical Laboratory 3X31, 3X32	4	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Fluid Mechanics 3M33	4	0
	Economic Organization 3A21	3	0
	Electives (see suggested list on p. 116)	0	2
	Total number of hours a term	20	18
FOURTH YEAR 37 HOURS	Heat-Power Engineerigg 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Electrical Laboratory 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	3	0
	Dynamics and Vibrations of Machinery 3D54	3	0
	Photoelasticity 3M55	2	0
	Advanced Machine Design 3D55	0	3
	Pressure Vessels 3D56 or *Welding in Design* 3D57	0	2
	Non-Resident Lectures 3G41	0	1
	Electives (see suggested list on page 116)	2	3
	Total number of hours a term	19	18

Grand total for the Four-Year Course ..... 150 hours

Option I. Elective Group of Studies or Thesis

In exceptional cases only, seniors who have made excellent records and can show a real need for specializing in Physics, Chemistry, Mathematics, or advanced work in Engineering, or in a field related thereto, may petition to be allowed to devote to such specialization the hours assigned to the group courses and electives in the other options.

Also, under this option, a limited number of well-qualified seniors may, upon petitioning, be allowed to substitute for either the special or the elective courses of one of the other options an investigation or research of importance and of broad educational value in Mechanical Engineering or in a field related thereto. The results of the investigation are to be embodied in a Thesis or Essay submitted in the manner and form required of graduate students.

A student desiring to take the special work under the provisions of this option must submit to the Director of the School and to the department principally concerned, a definite plan of the proposed work. The plan, which should be submitted in the Junior Year, must have definite objective and must state in detail the reasons for desiring the special work. Grand total for the Four-Year Course, 150 hours.

A Four-Year Course (B.S. in A.E)

A four-year course leading to the degree of Bachelor of Administrative Engineering is given in the School of Mechanical Engineering. Its significant feature is its coordination of technical instruction with instruction in industrial functions associated with engineering. This is described in detail on page 37. The work in non-technical subjects begins in the second year and continues in increasing amount throughout the third and fourth years, as shown by the courses of instruction printed in italics in the following outline.

		HOURS	
		First Term	*Second Term*
FIRST YEAR	See page 98	19	18
SECOND YEAR 39 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22	0	3
	Hydraulics 3M23	0	2
	Kinematics, Recitations 3D25	3	0
	Kinematics, Drawing 3D26	2	0
	Materials of Engineering 3X21, 3X22	3	3
	Machine Tool Processes 3S23	0	2
	Measuring Instruments 3S24	0	1
	English 2	0 or 3	3 or 0
	Technical Writing 3A33	2 or 0	0 or 2
	Industrial Statistics 3A41	0	3
	Business and Industrial Management 3A23	4 or 0	0 or 4
	Public Speaking 1	0 or 3	3 or 0
	Total number of hours a term	19	20
	In addition to these courses, sophomores are required to take Military Training.		
THIRD YEAR 35 HOURS	Heat-Power 3P33, 3P34	3	3
	Machine Design, Recitations 3D34	2	0
	Machine Design 3D35	0	2
	Mechanical Laboratory 3X33, 3X32	3	3
	Electrical Engineering 405, 406	4	4
	Industrial Accounting and Cost Finding 3A31	3	0
	Principles of Cost Control 3A47	0	3
	Industrial Relations 3A49	2	0
	Economic Organization 3A21	0	3
	Total number of hours a term	17	18
FOURTH YEAR 38 HOURS	Mechanical Laboratory 3X41, 3X42	4	4
	Heat-Power 3P54	0	2
	Industrial Engineering 3I43	3	0
	Motion and Time Study 3I54	0	2
	Standard Costs and Management Control 3A54	3	0
	Corporation Finance 3A34 or Economics 31	3 or 0	0 or 3
	Engineering Business Law 3A43, 3A46	3	2
	Industrial Marketing 3A44	3	0
	Business and Industrial Problems 3A48	0	2
	Personnel Management in Industry 3A42	2	0
	Non-resident Lectures 3G42	0	1
	Electives	0	4
	Total number of hours a term	21 or 18	17 or 20
	Grand total for the Four-Year Course	150 hours	

A Five-Year Course (B.M.E. or B.S. in A.E.)

A five-year course leading to the degree of Bachelor of Mechanical Engineering may be arranged to include all the work of any of the four-year courses which are outlined on pages 100 to 108, and in addition the equivalent of one year's work in other studies, generally in the College of Arts and Sciences, designed to broaden the student's training. There is no fixed schedule for such a program, since much depends upon the student's special interests. A possible arrangement is suggested in the table below. The option lectures and design courses provided for in the fifth year are to be chosen from one of the options of the regular four-year course. The entrance requirements are the same as for the regular four-year course. In this suggested program, provision for the elective courses is postponed until after the second year, when the student can exercise better judgment in selecting these courses.

A five-year program leading to the degree of Bachelor of Science in Administrative Engineering may be similarly arranged.

		HOURS	
		First Term	*Second Term*
FIRST YEAR	See page 98	19	18
SECOND YEAR	See page 98	18	20
THIRD YEAR 38 HOURS	Heat-Power Engineering 3P31, 3P32	3	3
	Mechanical Laboratory 3X31, 3X32	4	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Fluid Mechanics 3M33	4	0
	Electives	5	8
FOURTH YEAR 36 HOURS	Electrical Engineering 415, 416	3	3
	Economic Organization 3A21	0	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Heat-Power Engineering 3P41, 3P42	3	3
	Industrial Accounting and Cost Finding 3A31	0	3
	Electives	8	2
FIFTH YEAR 36 HOURS	Option Lectures	2	2
	Option Design	2	2
	Electrical Engineering 435, 436	2	2
	Heating, Ventilating, and Air Conditioning 3P48	3 or 0	0 or 3
	Non-resident Lectures 3G41	0	1
	Electives or option courses	9 or 12	12 or 9

Grand total for the Five-Year Course ..... 185 hours

A Five-Year Engineering-Physics Program (B.M.E.)

Students wishing to prepare for research and development work in certain engineering fields may find it advantageous to extend their courses of study over an extra year by adding a three-year sequence of related courses in physics. Entrance upon such a program should be made not later than the beginning of the third or junior year. Those interested should consult the Director of the School and the Chairman of the Department of Physics for further details. They will jointly approve and sponsor acceptable individual programs which should be mapped out in advance for a three-year period.

A Five-Year Course (B.M.E. and B.E.E.)

In various fields of practice and investigation the mechanical engineer often has use for a more extensive training in electrical engineering than can be included in a regular four-year course in mechanical engineering; similarly, the electrical engineer may desire to have had more instruction in heat-power engineering, hydraulic-power engineering, mechanics, experimental engineering, and other phases of mechanical engineering than can be given in a four-year electrical engineering course. To meet these broader requirements it may be possible to rearrange the required work in the respective four-year curricula in mechanical and electrical engineering so that both the B.M.E. and B.E.E. degrees may be obtained in a five-year period of study. The necessary readjustment of work for obtaining the two degrees must be made with the Directors of the Schools of Mechanical Engineering and Electrical Engineering, before the beginning of the student's second year. See the statement of the curriculum on page 142.

A Five-Year Course (B.M.E. and B.S. in A.E.)

A combination of the longer *technical* courses of the curricula in Mechanical Engineering (including one of the special options therein) and the non-technical subjects of the curriculum for Administrative Engineering may be arranged in a program which leads to the degree of B.M.E. at the end of the fourth year and to the B.S. in A.E. degree upon the completion of the fifth year. The program necessary for obtaining these two degrees in five years should be planned preferably before the beginning of the student's second year. The schedule is most readily arranged in combination with the M.E. Industrial Engineering Option which contains several of the special courses included in the Administrative Engineering curriculum. A sample arrangement of the program, based on the Industrial Option (Option C) and including the desired substitution of the four-hour course in Business and Industrial Management 3A23 for the three-hour course in Industrial Organization and Management 3A35a, follows:

		HOURS	
		First Term	*Second Term*
FIRST YEAR	See page 98	19	18
SECOND YEAR 37 HOURS	Same as the second year on page 98, except that Economic Organization 3A21 is substituted for courses 3S23 and 3S24. Note: It is desirable that English 2 and Public Speaking 1 be completed as early as possible. These courses may be taken in the Summer Session, if they can not be included in the term schedules. 3S23 and 3S24 may be taken in the Short Course following the close of either the freshman or the sophomore year.	18	19
THIRD YEAR 37 HOURS	Same as on page 102, except that Business and Industrial Management 3A23, 4 hours, is substitured for course 3A21 and the elective hours	17	20
FOURTH YEAR 39 HOURS	Same as for Option C, page 102, except that the total of elective hours should be increased to bring the grand total to 150 hours	19	20
FIFTH YEAR 37 HOURS	**Public Speaking* 1	0	3
	**English* 2	3	0
	**Technical Writing* 3A33	0	2
	**Industrial Statistics* 3A41	3	0
	**Standard Costs and Management Control* 3A54	3	0
	Corporation Finance 3A34, or Economics 31	0	3
	Engineering Business Law 3A43, 3A46	3	2
	Industrial Marketing 3A44	3	0
	Business and Industrial Problems 3A48	0	2
	Personnel Management in Industry 3A42	2	0
	Electives (see suggested list on page 116 or one of the other M.E. Options)	2	6
		19	18

Grand total for the B.S. in A.E. degree ..... 187 hours

*Unless previously completed, as would be desirable.

Similar programs may be arranged also with M.E. Options, A, B, D, and E, provided Cost Control 3A47 is completed before the fifth year. The elective hours available in the various options may be used for Administrative Engineering courses.

A Six-Year Course (A.B. followed by B.M.E. or by B.S. in A.E.)

In the six-year course leading to the degree of A.B. at the end of four years and to the B.M.E. or B.S. in A.E. in the mechanical field at the end of the sixth year, the entering student must meet the requirements of admission of the College of Arts and Sciences in which he is registered until he receives his first degree. In the last two years the student registers in Mechanical Engineering, or Administrative Engineering. While in the College of Arts and Sciences, the student must complete the freshman engineering subjects before his third year and he must complete the sophomore subjects in Mechanical Engineering, or in Administrative Engineering, before his fifth year, so that in his last two years, he may follow the regular junior and senior programs in the desired Engineering curriculum.

Advice and assistance in arranging the six-year program may be obtained by applying to the Director of the Sibley School of Mechanical Engineering and to the Dean of the College of Arts and Sciences.

One of the several possible arrangements of the A.B.–B.M.E. six-year program is outlined below. In it, the first two years include courses in English, foreign language, history, and laboratory science (chemistry and physics), which will meet requirements of the A.B. degree. These subjects and mathematics may be included in the required 90 hours of courses that must be taken in the College of Arts and Sciences for that degree. Courses in addition to the 90 hours may include the specified Engineering courses. If the entering student lacks any of the mathematics required for admission to engineering, the deficiency should be made up in the freshman year, and it may then be desirable to substitute Mathematics 55a, b, for Mathematics 60a, b, c, d, and make other adjustments in the program.

PROGRAM FOR A.B. AND B.M.E.

		HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 34 HOURS	Mathematics 1, 2, or 3 (if not offered for entrance)	3	0
	Mathematics 60a, 60b	3	3
	English	3	3
	Foreign Language	3	3
	History	3	3
	Metal Working 3S11	0	1
	Introductory Lectures on Engineering 3G11	1	0
	Hygiene 1, 2	1	1
	Elective (A. and S.)	0	3
	Total number of hours a term	17	17
SECOND YEAR 35 HOURS	Mathematics 60c, 60d	3	3
	Chemistry 102 or 104	3	3
	Physics 11, 12	4	4
	Public Speaking 1	3	0
	Economics or Social Science A	3	0
	Desc. Geom. and Drawing 3C11, 3C12	3	3
	Casting Processes 3S15	0	2
	Surveying 210A	0	1
	Total number of hours a term	19	16

Freshmen and sophomores are also required to take Military Training.

THIRD YEAR 36 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Strength of Materials 3M22b	0	2
	Kinematics 3D21, 3D23, 3D24	4	3
	Physics 21, 22	3	3
	*A. & S. Major and Electives	6	7
	Total number of hours a term	18	18
FOURTH YEAR 36 HOURS	Materials of Engineering 3X21, 3X22	3	3
	Applied Mathematics 3M24	0	3
	Machine Tool Processes 3S23	2	0
	Measuring Instruments 3S24	1	0
	*A. & S. Major and Electives	12	12
	Total number of hours a term	18	18

*Additional Mathematics, Physics, Chemistry (or Chemical Engineering), Economics, or Social Science are suggested.

FIFTH AND SIXTH YEARS — These would follow the respective junior and senior curricula as given for Mechanical Engineering.

PROGRAM FOR A.B. AND B.S. IN A.E.

One arrangement of program leading to the A.B. degree at the end of four years and to the degree of B.S. in A.E. in Mechanical Engineering at the end of the sixth year is as follows:

FIRST AND SECOND YEARS. Same as for the A.B.–B.M.E. combination (see just above).

		HOURS	
		First Term	*Second Term*
THIRD YEAR 36 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Hydraulics 3M23	0	2
	Kinematics 3D25, 3D26	5	0
	A. & S. Major and Electives	8	13
	Total number of hours a term	18	18
FOURTH YEAR 36 HOURS	Materials of Engineering 3X21, 3X22	3	3
	Technical Writing 3A33	0	2
	Industrial Statistics 3A41	0	3
	Business and Industrial Management 3A23	4	0
	Machine Tool Processes 3S23	2	0
	Measuring Instruments 3S24	1	0
	A. & S. Major and Electives	8	10
	Total number of hours a term	18	18

FIFTH AND SIXTH YEARS — These would follow the respective junior and senior curricula for Administrative Engineering.

Elective Subjects

Courses of instruction which are given in the Sibley School of Mechanical Engineering and which are open to election by students are indicated by title and number in the following list. The figures in the last two columns indicate the credit in hours for the first and second terms respectively.

Tool Engineering 3D51	0	2
Advanced Kinematics and Kinetics 3D52	0	3
Materials Handling 3D53	0	2
*Dynamics and Vibrations of Machinery 3D54	3	0
Advanced Machine Design 3D55	0	3
Design of Pressure Vessels 3D56	0	2
Welding in Machine Design 3D57	0	2
Special Investigations in Machine Design 3D59	As arranged	
Aerodynamics 3B35	0	2
Airplane Design 3B46	2	0
Automotive Lectures 3B41, 3B42	2	2
Ordnance Problems 3M53 (one hour a term for two years)	1	1
Photoelasticity 3M55	2	0
*Applied Elasticity 3M56, 3M57	3	3
*Mechanics of Vibrations 3M58	3	0
*Seminar in Applied Mechanics, 3M59	1	1
*Theory of Elastic Stability 3M60 (not given in 1942–43)	3	0
*Advanced Fluid Mechanics 3M61	0	3
Steam and Oil-Engine Power Plants 3P44, 3P45	2	2
Heating, Ventilating, and Air-Conditioning	0 or 3	3 or 0
Refrigeration 3P49	2	0
Power Plant Economics 3P50	2	0
Steam Turbines 3P51	0	2
Internal Combustion Engines 3P52	2	0
Graphical Computations and Representations 3P55	2	0
*Advanced Heat-Power Engineering 3P61, 3P62	2	2
*Advanced Thermodynamics 3P63	0	2
*Temperature Measuring Instruments 3X53	2 or 0	0 or 2
*Experimental Engineering Research 3X51	1 to 3	1 to 3
Applied Metallography 3X52	2	0
Industrial Relations 3A49	2	0
Corporation Finance 3A34	0	3
A. S. M. E. Credit 3G51	0	1
Engineering Journalism 1J41, 42	1	1
Advanced Industrial Engineering 3I51	1 to 3	1 to 3
Industrial Auditing 3I52	0	2
Motion and Time Study 3I54	2 or 0	0 or 2
Engineering Business Law 3A50	0	2
Industrial Marketing 3A45	0	2
Industrial Engineering Economy 3I48	0	2
Principles of Cost Control 3A47	0	3
Engineering Business Law 3A43, 3A46	3	2
Industrial Statistics 3A41	0 or 3	3 or 0
Advanced Materials Processing 3S50	As assigned	
*Advanced Heat-Power Engineering Research 3P70	As assigned	
*Business and Industrial Research 3A51	As assigned	
*Advanced Automotive Engineering 3B50	As assigned	

**Elective Subjects for Graduates and Advanced Students.*

Following is a list of courses of instruction, given in other Schools of the College of Engineering or in other colleges of the University, which may be elected by students of the Sibley School of Mechanical Engineering:

Elements of Structural Engineering 279	0	2
Advanced Hydraulics 241	0	3

Hydraulic Measurements 242	3	0
Foundations 281	0 or 3	3 or 0
Engineering Law 290	0 or 3	3 or 0
Electrical Power Plants 441	3	0
Industrial Applications and Control 462	0	2
Illumination 465, 466	2	2
Elementary Differential Equations 41	0 or 3	3 or 0
Patents 489	1	0
Advanced Calculus 42	3	3
Introductory Qualitative Analysis 210	0 or 3	3 or 0
Introductory Quantitative Analysis 225	0 or 3	3 or 0
Introductory Physical Chemistry (Lect.) 405	3	3
Introductory Physical Chemistry (Lab.) 410	3	3
Introductory Chem. Microscopy (Lect. and Lab.) 530	0 or 3	3 or 0
Introductory Metallography 545	3	0
Advanced Metallography, Chem. 550	0	3
Gas and Fuel Analysis 250	0	3
Modern Physics 41	2	0
Special Topics in Modern Physics 42	0	2
Physics courses dependent upon prerequisites (Consult the Department)		
Introductory Geology 100	3 or 0	0 or 3
Engineering Geology 501	4 or 0	0 or 4
Money and Banking, Ec. 11	3 or 0	0 or 3
Concrete and Concrete Materials 227A	0 or 1	1 or 0
Industrial Hygiene 5	1	0
Public Speaking 1	3 or 0	0 or 3

For other subjects, such as Languages, History, Philosophy, Psychology, Government, Astronomy, Biology, Botany, Archaeology, Music, see the Announcements of the colleges concerned.

Note. Not more than four hours credit for elective work in Advanced Military Science and Tactics will be accepted toward meeting the degree requirements in any Course or Option in the School of Mechanical Engineering.

The Courses of Instruction

The courses of instruction in the following list are designed for students in the Sibley School of Mechanical Engineering. The courses in Chemistry, Economics, English, Mathematics, Physics, and Public Speaking are given in the College of Arts and Sciences, and those in Civil and Electrical Engineering in the respective Schools of the College of Engineering.

CHEMISTRY

General Chemistry. 102. See page 164.

General Chemistry. 104. See page 165.

ENGLISH

English 2. Required of all sophomores in Administrative Engineering. Either term. Credit three hours. The aim of the course is to increase the student's ability to communicate his own thoughts and to understand the thoughts of others. Professor SIBLEY and others.

MATHEMATICS

Analytical Geometry and Calculus 55a, 55b. See page 165.

PHYSICS

General Physics 11, 12. See page 165.
General Physics 21, 22. See page 166.

PUBLIC SPEAKING

Public Speaking 1. Either term. Credit three hours. Required of students in Administrative Engineering. For description, see page 166.

CHEMICAL ENGINEERING

Introductory Metallography, Chem. Eng. 545. See page 159.
Advanced Metallography, Chem. Eng. 550. See page 159.

CIVIL ENGINEERING

Elementary Surveying 210A. See page 75.

ELECTRICAL ENGINEERING

E.E. 405, 406. *Fundamentals of Electrical Engineering.* See page 148.
E.E. 415, 416. *Principles of Electrical Engineering.* See page 149.
E.E. 435, 436. *Electrical Laboratory for M.E. Seniors.* See page 150.

For elective courses in other schools and colleges of the University, see the list of elective subjects, page 116, and the Announcements of the University's schools and colleges.

ADMINISTRATIVE ENGINEERING (A)

3A21. *Economic Organization.* First term for M.E. juniors; second term for E.E. and A.E. juniors. Credit three hours. Lectures, collateral reading, and discussion periods. A study of the form and functioning of the arrangements by which men work together in economic production, and apportion the resulting product. Professor GARRETT and Mr. MITCHELL.

3A23. *Business and Industrial Management.* Required of all sophomores in Administrative Engineering. Either term. Credit four hours. Four lecture-discussion periods a week with regularly assigned problems. This course surveys present-day management problems of business and industrial organizations. It deals with the establishment of business policies, types of ownership and forms of control, together with the functions of finance, machine production, accounting, and marketing. An introductory treatment is given to problems of plant location, factory layout, time and motion study, wage systems, cost systems, industrial relations, and industrial marketing, all of which will be developed in greater detail by subsequent courses. Considerable emphasis is placed upon a discussion of the principles of advertising. Professor BANGS and Mr. SAMPSON.

3A31. *Principles of Industrial Accounting and Cost Finding.* Required of all A.E. juniors and M.E. juniors. Given first term for A.E. and second term for M.E. Credit three hours. Two recitations and one 2½-hour computing period a week. Theory of debits and credits; development of books of original entry; controlling accounts; voucher system; analysis of financial statements; business papers; modern mechanical methods of performing the ac-

counting function; elements of cost finding. Professor BANGS, Associate Professor HANSELMAN, and Messrs. SCOTT, WHITESEL, and OTTO.

3A33. *Technical Writing.* Required of all sophomores in Administrative Engineering. Either term as assigned. Two recitations a week. Credit two hours. A study of the forms of written expression with emphasis on those most frequently used in business and engineering: the writing of technical reports, articles, and editorials; the composition of business letters, such as credit, collection, inquiry, quotation, adjustment, and sales letters. Mr. SAMPSON.

3A34. *Corporation Finance.* Required of all seniors in Administrative Engineering, elective for upperclassmen in Mechanical Engineering. Second term. Credit three hours. Prerequisite courses 3A21 and 3A31.

A study of the financial problems of the business corporation from the points of view of the management, the investor, and the public. Professor O'LEARY.

3A35a. *Industrial Organization and Management.* Required of all sophomores or juniors in Mechanical and Electrical Engineering. Either term. Credit three hours. A lecture-discussion course with regularly assigned problems and collateral reading. This course surveys present-day management problems of business and industrial organizations. It deals with the establishment of business policies, types of ownership, and forms of control, together with the functions of finance, machine production, accounting, and marketing. Consideration is given to problems of the selection of a plant site, factory layout, time and motion study, wage systems, cost systems, industrial relations, and industrial marketing. Professor BANGS and Mr. SAMPSON.

3A41. *Elementary Industrial Statistics.* Required of all sophomores in Administrative Engineering. First or second term. Credit three hours. Two recitations and one 2½-hour computing period a week. The elements of the technique of statistical analysis. Probability, reliability, correlation, and variance analysis applied to engineering and industrial problems. Time series and index numbers. Professor GARRETT and Assistant Professor LOBERG.

3A42. *Personnel Management in Industry.* Required of all seniors in Administrative Engineering. First term. Credit 2 hours. One recitation and one computing period each week. A study of human nature in business and industry involving the psychological approach. Case demonstrations of business and industrial situations are used to illustrate the more important problems. Professor BANGS and Dr. RYAN.

3A43. *Engineering Business Law.* Required of all seniors in Administrative Engineering. First term. Credit three hours. Three lecture-discussion periods a week. A study of the fundamental legal principles which relate to the usual business transactions with emphasis on the law of contracts. By the use of adequate case material the student is aided in his application of the general legal principles to specific situations. Associate Professor HANSELMAN.

3A44. *Industrial Marketing.* Required of all seniors in Administrative Engineering. First term. Credit three hours. Two recitations and one lecture a week. A study of the field of industrial marketing using the case method of instruction. The scope of the course includes product planning, policy, and research; sales and market analysis; distribution channels; pricing and terms

of sales; sales promotion; management and organization of sales force; sales control. Assistant Professor LOBERG.

3A45. *Industrial Marketing.* Elective. Second term. Credit two hours. One recitation and one 2½-hour laboratory period a week. Prerequisite course 3A44. The application of the principles of marketing to specific problems. Each student will develop a complete market study and analysis for given industrial products. Assistant Professor LOBERG.

3A46. *Engineering Business Law.* Required of all seniors in Administrative Engineering. Second term. Credit two hours. Two lecture-discussion periods a week. A study of fundamental legal principles relating to the usual business transactions with special emphasis on the laws of Sales and Corporations. By the use of adequate case material the student is aided in his application of general legal principles to specific situations. Associate Professor HANSELMAN.

3A47. *Principles of Cost Control.* Required of all juniors in Administrative Engineering and of Mechanical Engineering seniors electing the Industrial Engineering Option. Second term. Credit three hours. Prerequisite course 3A31 or its equivalent. Continues the work of 3A31 covering in detail manufacturing cost systems applied in the laboratory by problems dealing with order costs and process costs; a discussion of budgets and statements. Associate Professor HANSELMAN and Messrs. SCOTT and WHITESEL.

3A48. *Business and Industrial Problems.* Required of all seniors in Administrative Engineering. Second term. Credit two hours. Prerequisite courses 3A21, 3A23, 3A31, 3A47, 3A41, 3A43, 3A44. A series of case studies of problems occurring during the launching and conduct of a small manufacturing enterprise. The attempt is made in this way to tie together the work previously taken in economics, statistics, accounting, marketing, business law, and human relations. Professor GARRETT.

3A49. *Industrial Relations.* Required of all juniors in Administrative Engineering and of Mechanical Engineering seniors electing the Industrial Engineering Option. First term. Credit two hours. Two lectures or recitations a week. Prerequisite course 3A35a, or 3A23. A discussion of the more important problems which arise from the relation of employer and employee under present conditions of industry. Such features are considered as the effect of organized labor, methods of wage payment, committee systems, and industrial education. Professor GARRETT.

3A50. *Engineering Business Law.* Elective. Second term. Credit two hours. Two lecture-discussion periods a week. A study of fundamental legal principles relating to common business transactions with special emphasis on the laws of Agency and Negotiable Instruments. By the use of adequate case material the student is aided in his application of general legal principles to specific situations. Associate Professor HANSELMAN.

3A51. *Business and Industrial Research.* Elective. Either or both terms. Credit one hour for forty hours of actual work. Open to a very limited number of seniors and graduate students who have shown by training and aptitude their ability to carry on original investigations in business and industrial subjects. Professors BANGS and GARRETT, Associate Professor HANSELMAN, and Assistant Professor LOBERG.

3A52. *Industrial Salesmanship.* Elective. Second term. Credit two hours.

One recitation and one 2½-hour laboratory period a week. A study of the basic principles of selling and the application of these principles to case problems. Assistant Professor LOBERG.

3A53. *Chemical Engineering Economics.* Required of fourth or fifth year students in Chemical Engineering. First term. Credit three hours. Two recitations and one 2½-hour computing period each week. A course primarily for Chemical Engineers, it includes a development of elementary accounting theory sufficient to enable discussion of Cost Accounting as applied to chemical plants, of statement structure and analysis, and other problems peculiar to the chemical industry. Associate Professor HANSELMAN.

3A54. *Standard Costs and Management Controls.* Required of all seniors in Administrative Engineering. First term. Credit three hours. One lecture and two 2½-hour computing periods a week. Prerequisite course 3A47. A detailed study of standard costs applied to manufacturing, selling, and administrative functions followed by a discussion of industrial control of production and sales through costs. In addition income tax methods are studied. Associate Professor HANSELMAN.

AUTOMOTIVE AND AERONAUTICAL ENGINEERING (B)

3B35. *Aerodynamics.* Juniors. Required in Option E. Second term. Credit two hours. Prerequisite courses 3M21 and 3M22a and b. Two recitations a week. Properties of air, airfoil characteristics, drag calculations, engine-propeller characteristics and their relation to airplane performance. Stability calculations, performance estimates, and flight testing. Mr. KOCH.

3B41. *Automotive Lectures.* Seniors and graduates. Required in Option D. First term. Credit two hours. Two lectures a week. Prerequisite course 3P31 or 3P33, 3D31, 32, 33. The automobile, and the power required for its operation, but not including the power plant (for which see course 3B42). Analysis is made of the relations of the car to the road; functions of steering, driving, braking; mechanical efficiency of chassis; springing for comfort of riding; wind resistance; layout of parts for balanced design. Professor UPTON.

3B42. *Automotive Lectures.* Seniors and graduates. Required in Options D and E. Second term. Credit two hours. Two lectures a week. Prerequisite courses 3P31 or 3P33, 3D31, 3D32, 3D33. Analysis of automotive power plant design and operation; nature of the actual working fluid; preparation for and control of combustion in spark- and compression-ignition engines; volumetric, thermal, and mechanical efficiencies of engines; lubrication, fuels, etc. Professor UPTON.

3B43. *Automotive Computations.* Seniors and graduates. Required in Option D. First term. Credit two hours; two computing periods a week. Must be accompanied by course 3B41, which it parallels, but with more detailed studies to acquaint students with methods of attack on problems in operation or design. Professor UPTON.

3B44. *Automotive Power Computations.* Seniors and graduates. Required in Option D. Second term. Credit two hours; two computing periods a week. Must be accompanied by 3B42, which it parallels, but with more detailed studies in operation and design. Professor UPTON.

3B46. *Airplane Design.* Seniors. Required in Option E. First term. Credit two hours. Prerequisite 3B35. Two recitations a week. Layout procedure,

weight and balance estimates, load factors, materials, and costs. Principles of stress analysis and airplane computations. Mr. Koch.

3B47, 3B48. *Airplane Computations*. Seniors. Required in Option E. Throughout the year. Credit two hours a term. Prerequisite course 3B35; and must be accompanied or preceded by 3B46. Two computing periods a week. The student makes calculations and drawings similar to those required by the Department of Commerce for approval of the design of an airplane. Mr. Koch.

3B50. *Advanced Automotive Engineering*. Elective for qualified seniors and graduates. Either term. Credit two to five hours as arranged. Selected advanced topics and special problems as arranged. Professor Upton and Mr. Koch.

DRAWING AND DESCRIPTIVE GEOMETRY (C)

3C11. *Drawing and Descriptive Geometry*. Required of candidates for the degree of B.E.E. or B.M.E. or B.S. in A.E. with special reference to either E.E. or M.E. First term. Credit three hours. One recitation and two 2½-hour drawing periods a week.

Coordinated instruction in subjects prerequisite to a study of the engineering applications of drawing. The drafting arts. Geometric analysis and composition of structures including considerations of the elements of structure and their properties, interspace relations of structural elements, determinants of elements and structural organization along paths of physical and functional ties. Graphic computation and description of the geometric qualities and quantities of structure. Professor Townsend, Associate Professor Cleary, and instructors. *East Sibley*.

3C12. *Mechanical Drafting*. Required of candidates for the degree of B.E.E. or B.M.E. or B.S. in A.E. with special reference to either E.E. or M.E. Second term. Credit three hours. One recitation and two 2½-hour drawing periods a week. Prerequisite course 3S11 and must be taken with or preceded by courses 3C11 and 3S14 or 3S15.

Basic studies of the functional and structural divisions of machines, structural standards and shop methods of producing structural qualities and quantities are coordinated in this course with instruction and drill in the fundamental techniques of determining machine structure by layouts and specifying structural information on working drawings in a manner consistent with both the convenience of the shop and the need of restricting the accumulation of production errors. Freehand sketching, pictorial drawing, tracing, etc. are studied and applied in this work.

This is the first course in the engineering curriculum which deals with a subject of express engineering application. Students who become proficient in this subject are eligible for employment as junior mechanical draftsmen and are thus afforded their first opportunity for summer work of recognized value as basic training in the field of engineering practice. The benefits to be derived when studies of fundamentals are overlapped with practical experience are of such importance that every eligible student should attempt to take advantage of this opportunity. Professor Townsend, Associate Professor Cleary, and instructors. *East Sibley*.

3C14, 3C15. *Drawing*. Required of candidates for the degree of Bachelor of Chemical Engineering. Throughout the year. Credit two hours a term. One recitation and one two and one-half hour drawing period a week. A

brief course in the basic subjects of drawing and the techniques of applying these subjects to the determination of structure by layouts and the specification of structure on working drawings. Professor TOWNSEND, Associate Professor CLEARY, and instructors. *East Sibley.*

MACHINE DESIGN (D)

3D21. *Kinematics, Recitations.* Sophomores in Mechanical Engineering. First term. Credit two hours. Prerequisite courses, Drawing and Descriptive Geometry 3C11, Mechanical Drafting 3C12, and Mathematics 55a and 55b. Two recitations a week throughout the term on the theory of motion; the transmission of motion; the instant center method of determining linear and angular velocities; vector method of determining linear and angular velocities and accelerations; cams; rolling curves and friction gearing; etc. Professor ROGERS and Messrs. MORRIS, HINKLE, and JOHNSON.

3D23. *Kinematics, Drawing.* Sophomores in Mechanical Engineering. First term. Credit two hours. Must be taken with course 3D21. Prerequisite courses, Drawing and Descriptive Geometry 3C11, Mechanical Drafting 3C12, and Mathematics 55a and 55b. Two drawing periods a week throughout the term devoted to drawing-board applications of the theory and principles of course 3D21. Professor ROGERS and Messrs. MORRIS, HINKLE, JOHNSON, CARRIER, and MOLT.

3D24. *Kinematics, Recitations and Drawing.* Sophomores in Mechanical Engineering. Second term. Credit three hours. Prerequisite course 3D21. Two recitation periods and one drawing-room period a week throughout the term. Recitation and drawing-board work dealing with gears and gear cutting; linkwork and miscellaneous mechanisms: belt, rope, and chain drives; and trains of mechanism. Professor ROGERS and Messrs. MORRIS, CARRIER, and MOLT.

3D25. *Kinematics, Recitations.* Sophomores in Electrical and Administrative Engineering. First term. (Make-up section, second term.) Credit three hours. Prerequisite courses, Drawing and Descriptive Geometry 3C11, Mechanical Drafting 3C12, and Mathematics 55a and 55b. Three recitations a week throughout the term on the theory of motion; the transmission of motion; the instant-center method of determining linear and angular velocities; cams; rolling curves and friction gearing; gears and gear cutting; linkwork and miscellaneous mechanisms; belt, rope, and chain drives; and trains of mechanism. Professor ROGERS, and Messrs. MORRIS, GATCOMBE, CARRIER, and MOLT.

3D26. *Kinematics, Drawing.* Sophomores in Electrical and Administrative Engineering. First term. Credit two hours. Must be taken with course 3D25. Prerequisite courses, Drawing and Descriptive Geometry 3C11, Mechanical Drafting 3C12, and Mathematics 55a and 55b. Two drawing periods a week throughout the term devoted to drawing-board applications of the theory and principles of course 3D25. Professor ROGERS, and Messrs. GATCOMBE, HINKLE, JOHNSON, CARRIER, and MOLT.

3D31a. *Machine Design, Recitations.* Juniors in Mechanical Engineering. First term. Credit three hours. Prerequisite courses 3D21, 3D23, 3D24, 3X21, 3X22, 3M21 and 3M22a and 3M22b. Three recitations a week throughout the term on the theoretical and practical applications of kinematics, ma-

terials, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as suitability of materials, safety, lubrication, construction, etc. Associate Professor BLACK and Mr. HINKLE.

3D32a. *Machine Design, Recitations.* Juniors in Mechanical Engineering. Second term. Credit two hours. Prerequisite course 3D31a. Two recitations a week throughout the term on the theoretical and practical applications of kinematics, materials, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as suitability of materials, safety, lubrication, construction, etc. Associate Professor BLACK and Messrs. GATCOMBE and HINKLE.

3D33a. *Machine Design.* Juniors in Mechanical Engineering. Second term. Credit two hours. Must be taken with course 3D32a. Perequisite course 3D31a. Two design periods a week throughout the term. The student for the first time undertakes the design of machine parts and assemblies and makes all the necessary calculations and drawings. Orderly, systematic calculations are insisted upon and such layout and detail drawings are made as are found necessary to complete each problem. Associate Professor BLACK, and Messrs. GATCOMBE and HINKLE.

3D34. *Machine Design, Recitations.* Juniors in Electrical and Administrative Engineering and Seniors in Chemical Engineering. First term. (Make-up section, second term.) Credit two hours. Prerequisite courses 3D25, 3D26, 3X21, 3M21, and 3M22a for Electrical and Administrative Engineers and 3C15, 3X21, 3M21, and 3M22a for Chemical Engineers. Two recitations a week throughout the term on the theoretical and practical applications of kinematics, materials, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as lubrication, safety, suitability of materials, construction, etc. Professor ALBERT, and Messrs. GATCOMBE and JOHNSON.

3D35. *Machine Design, Drawing.* Given the second term to Junior Administrative Engineers. Credit two hours. Must be taken with course 3D34 **or in** the term following. Prerequisite courses 3D25, 3D26, 3X21, 3X22, 3M21, and 3M22a. Two design periods a week throughout the term. The student for the first time undertakes the design of machine parts and assemblies and makes all the necessary calculations and drawings. Orderly systematic calculations are insisted upon, and such layout and detail drawings are made as are found necessary to complete each problem. Professor ALBERT, and Messrs. GATCOMBE and JOHNSON.

3D36. *Machine Design, Drawing.* Seniors in Chemical Engineering. Second term. Credit one hour. Prerequisite courses 3C15, 3X21, 3X22, 3M21, 3M22a, and 3D34. One drawing period a week throughout the term. Design of a unit of equipment peculiar to a chemical industry. Orderly systematic calculations are insisted upon and such layout and detail drawings are made as are found essential to the problem. Mr. JOHNSON.

3D51. *Tool Engineering.* An elective for juniors and seniors in engineering. Second term. Credit two hours. One discussion and one computing period a week. The course deals with the theory and principles of operation underlying the design of punches, dies, jigs, and fixtures and with the application of such tools to the production of parts of appliances and machines in small and in large quantities. Mr. JOHNSON.

3D52. *Advanced Kinematics and Kinetics.* An elective for juniors, seniors, and graduates. Second term. Credit three hours. Prerequisite courses 3D21, 3D23, and 3D24, or 3D25 and 3D26. About twenty-four lecture and discussion periods and about twenty-one three-hour drawing periods during the term, for which two one-hour and two three-hour periods a week must be provided in the student's schedule. Graphical and semi-graphical treatment of linear and angular velocities and accelerations and of the resulting forces, stresses, and strains due to the form and mass of the moving parts of mechanisms and machines. Vibration and critical speeds and the theoretical basis and use of balancing machines for securing static and running balance of machine parts will be treated as far as time permits. (Not given in 1942–43.) Professor ROGERS.

3D53. *Materials Handling.* An elective for juniors, seniors, and graduates. Second term. Credit two hours. Prerequisite courses 3D21, 3D22, and 3D24, or 3D25 and 3D26. Two lectures a week throughout the term. Treatment and analysis of the known methods of handling different kinds of materials and of the principles and considerations involved in a proper choice of the method of handling any given kind of material. (Not given in 1942–43.)

3D54. *Dynamics and Vibrations of Machinery.* Elective for seniors and graduates. Required in Option H. First term. Credit three hours. Prerequisite courses 3D32 or 3D34. Two lecture and discussion periods and one computing period a week throughout the term. Graphical and analytical treatment of velocities, accelerations, static forces, inertia forces, and combined forces. Balancing of engines. Transverse and torsional vibrations, critical speeds, and balancing machines. Determination of forces in automotive engines. Associate Professor BLACK.

3D55. *Advanced Machine Design.* Elective for seniors and graduates. Required in Option H. Second term. Credit three hours. Prerequisite courses 3D32 or 3D34. Three lecture and discussion periods a week throughout the term. Advanced problems in stress analysis of machine and structural members including consideration of fatigue, creep, stress concentration, stability, etc. Vibration and lubrication. Special problems. Associate Professor BLACK.

3D56. *Design of Pressure Vessels.* An elective for seniors in engineering and an alternative course for Option H. Second term. Credit two hours. One discussion and one computing period a week. The course deals with the design of thin and thick pressure vessels under internal or external pressure, or both, and with the stresses in such vessels and in flat plates, flanges, heads, openings, and connections. Mr. CARRIER.

3D57. *Welding in Machine Design.* An elective for seniors in engineering and an alternative course for Option H. Second term. Credit two hours. One discussion and one computing period a week. The course deals with flame cutting and methods of welding, with shrinkage, warpage, and stress relieving, with inspection and testing, with the design of welded joints, and with the application of fusion welding in the design of appliances and machines. Professor ALBERT.

3D59. *Special Investigations in Machine Design.* Either or both terms. Credit as arranged. Opportunity is offered to qualified students, individually or in small groups, to pursue, under direction, special investigations in machine design and related fields. Professors ALBERT, ROGERS, or BLACK.

EXPERIMENTAL MECHANICAL ENGINEERING

(See the courses listed under the letter X, below)

GENERAL COURSES (G)

3G11. *Introductory Lectures.* Freshmen. Credit one hour. One lecture a week. This course of lectures is designed to introduce the first-year men to the various fields of engineering, and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lectures to awaken the interest of the freshmen in their chosen profession through the aid of vivid description, of stimulating biography, and of personal experience. *Lecture room to be assigned in the fall.*

3G41. *Non-resident Lectures.* Required for graduation of all seniors in Mechanical and Administrative Engineering. These lectures are given at some hour in the day specially set aside in the senior schedules. Seniors may also be required to attend certain of the non-resident lectures given in E.E. 4G41. Notices of the lectures will be posted on the bulletin board of the Sibley School of Mechanical Engineering. A notebook showing a résumé of each lecture attended (not more than one page for each lecture) must be handed in at the Director's office during block week at the end of the second term.

3G51. *A. S. M. E. Student Branch.* Sophomores, juniors, and seniors in Mechanical Engineering are urged to become members of the Student Branch of the American Society of Mechanical Engineers, the meetings of which, however, are open to all. Attendance at any fourteen Branch meetings entitles the member to one hour elective credit. Applications for membership should be made at the Director's Office in October of each year, or to the Honorary Chairman of the Student Branch.

HEAT-POWER ENGINEERING

(See the courses listed under the letter P, below)

INDUSTRIAL ENGINEERING (I)

3I43. *Industrial Engineering.* First term. Credit three hours. One lecture and two 2½-hour laboratory periods a week. Required of all Administrative Engineers and of Mechanical Engineers electing the Industrial Option. The laboratory work consists mainly of a study built around a case problem which concerns, in a specific and detailed manner, the location and layout of a factory for the production of automobile transmissions, supplemented with problems on materials handling equipment, time and motion study, plant organization, etc. The lectures cover the major features of modern industry as well as specific problems concerning the laboratory work. Associate Professor MILLARD and Messrs. MABIE and BURLEIGH.

3I44. *Industrial Engineering.* Second term. Credit three hours. One lecture and two 2½-hour laboratory periods a week. Prerequisite course 3I43. Required of all Mechanical Engineers electing the Industrial Option. Elective for seniors. A series of typical industrial problems dealing with modern production, such as machine rate, production and materials control, wage payments, equipment selection, work simplification, etc. For the most part these problems are based on the work done in course 3I43. Assistant Professor MILLARD and Mr. MABIE.

3I48. *Industrial Engineering Economy*. Second term. Credit two hours. Two recitation and discussion periods a week. Prerequisite courses 3I43 and 3A31 or its equivalent. Required of all Mechanical Engineers electing the Industrial Option. Elective for seniors. A consideration of problems in engineering economy is approached by the question, "Will it Pay?" Associate Professor MILLARD and Mr. BURLEIGH.

3I51. *Advanced Industrial Engineering*. Elective. Either or both terms. Credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates. Special problems and investigations which are carried on under the direction of members of the department staff. Associate Professor MILLARD.

3I52. *Industrial Auditing*. Elective. For seniors and graduates. Credit two hours. One lecture and one computing period a week, second term. Prerequisite course—Accounting for Engineers 3A31 or its equivalent. A study of auditing theory and practice by the use of illustrative problems pertaining to manufacturing concerns. Associate Professor MILLARD.

3I54. *Motion and Time Study*. Required of A.E. seniors in M.E. Elective for others. Either term. Credit two hours. One recitation and one 2½-hour laboratory period each week. Prerequisite Courses 3A35 or 3A23. The course consists of four major parts: (1) Process Charts, (2) Time Study, (3) Motion Study, and (4) Micro-Motion Analysis. The fundamentals of each of these parts are thoroughly covered in the recitations, while the laboratory, which is co-ordinated with the recitations, is devoted to practical applications. All types of process charts are made. Time studies are taken in the laboratory as well as in the shop. Motion economy is studied by the development of a specific problem in the laboratory during which motion pictures are taken and the operations studied. Through the use of micro-motion analysis of these pictures, an improved method of performance is developed which leads to the final result as represented by a simo-motion chart. Associate Professor MILLARD and Messrs. MABIE and BURLEIGH.

MACHINE DESIGN

(See the courses under the letter D, above)

MATERIALS PROCESSING

(See the courses under the letter S, below)

MECHANICAL LABORATORY

(See the courses under the letter X, below)

MECHANICS OF ENGINEERING (M)

3M21. *Theoretical and Applied Mechanics*. Sophomores. First term. Credit five hours. Five recitations a week. Prerequisites, passing grades in Mathematics 55a and 55b. Principles of Statics; forces and couples in a plane and in space; virtual displacements; applications to structures and mechanisms. Principles of Dynamics; analysis of translational and rotational motion of particles and rigid bodies; velocity, acceleration, momentum, impulse, work and energy, with engineering applications. Professor CORNELL, Assistant Professors PERKINS, LEE, and THOMSON, Dr. DRUCKER, Messrs. BOGEMA, SYMONDS, and MANSKY.

3M22a. *Strength of Materials.* Sophomores. Nine weeks of second term. Credit three hours. Five recitations a week. Prerequisite course 3M21. Stress, strain; strength and elastic properties of materials in tension, compression and shearing; riveted joints; torsion of shafts; helical springs; shear, moment, safe loading, and deflection of simple beams; special beams; eccentric loads; columns; impact loads. Professors CORNELL, GOODIER, Assistant Professors PERKINS, LEE, and THOMSON, Dr. DRUCKER, Messrs BOGEMA, SYMONDS, and MANSKY.

3M22b. *Strength of Materials.* Sophomores in Mechanical Engineering. Six weeks of second term. Credit two hours. Five recitations a week. A continuation of course 3M22a. Continuous beams; combined stresses; principal stresses; Mohr's circle of stress; theories of failure; thick walled cylinders; curved bars; unsymmetrical bending. Professor GOODIER, Assistant Professors PERKINS, LEE, and THOMSON, Dr. DRUCKER, and Mr. SYMONDS.

3M23. *Hydraulics.* Sophomores in Administrative and Electrical Engineering. Six weeks of second term. Five recitations a week. Credit two hours. Prerequisite course 3M21. Hydrostatics: pressures and centers of pressure. Hydrokinetics: general equations of energy; orifices, weirs, nozzles, Venturi meters, etc.; losses of head; flow in pipes; forces on stationary and moving bodies. Professor CORNELL, Assistant Professors PERKINS and THOMSON, Messrs. BOGEMA and SYMONDS.

3M24. *Applied Mathematics.* Sophomores in Mechanical Engineering. Second term. Credit three hours. Prerequisite course 3M21. Three recitations a week. Manipulation of data and reduction to empirical equations; elementary differential equations and applications to a variety of engineering problems, including free and forced vibration of the simpler mechanisms and structures. Professor GOODIER, Assistant Professors LEE and THOMSON, Dr. DRUCKER and Mr. SYMONDS.

3M33. *Fluid Mechanics.* Juniors in Mechanical Engineering. First term. Credit four hours. One lecture or examination, and three recitations a week. Applications of hydrostatics; steady motion of fluids through orifices, weirs, pipes, and channels; dimensional analysis and theory of model tests; principles of hydraulic turbines and centrifugal pumps. Assistant Professors PERKINS and THOMSON, and Mr. BOGEMA.

3M53. *Ordnance Problems.* Two lectures a week throughout one year, when taken as an elective engineering subject only. Also constitutes classroom requirements of first year of two-year advanced course in Ordnance R.O.T.C. Unit. In the latter case, one additional hour a week of military training is required. In either case, credit of one hour each term. Prerequisite courses 3M21 and 3M22a. First term covers ammunition and explosives; design and manufacturing methods; ballistics. Second term: other ordnance material, including small arms, artillery, essentials of carriage design, and ordnance vehicles. LIEUT. WHITE.

3M55. *Photoelasticity.* Elective for seniors and graduates. First term. Credit two hours. One lecture and one laboratory-lecture period each week. Prerequisite course 3M22b. Optics of photoelasticity; plane and circularly polarized light, monochromatic and white light, fringes, isochromatics and isoclinics; discussion of models, materials, and preparation. Elements of elasticity, including equilibrium and compatability equations for plane stress,

and stress functions; methods for determining principal stresses from photoelastic observations and computations, isopachics. In the laboratory, experiments on the calibration of color and fringe scales by tension, compression, and bending, are followed by tests on centrally loaded beams, and the determination of stress concentration factors and the separation of principal stresses. Dr. DRUCKER.

3M56, 3M57. *Applied Elasticity*. Elective for graduates. Open to qualified undergraduates. Throughout the year. Credit three hours each term. Three lectures a week. Prerequisites, 3M22a, 3M22b, 3M24 or 224-A, or Mathematics 200 or Mathematics 70. General theorems of the elastic solid, reciprocal theorem, sudden loading; tension, flexure and torsion of bars of arbitrary section; Castigliano's theorem with application to frames, rings loaded in and normal to plane, spiral and helical springs; stress in thick cylinders and discs due to pressure, heating, and rotation; beams on elastic foundations; symmetrical deformation of thin tubes; propagation of stress waves in bars.

In the second term, the topics are chosen from: Thermal stress; stress-analysis, stability and vibration, of plates and shells; vibration of beams. Professor GOODIER.

3M58. *Mechanics of Vibration*. Elective for seniors and graduates. First term. Credit three hours. Prerequisite, Course 3M24. The characteristic phenomena of mechanical vibrations encountered in engineering, and their quantitative investigation, illustrated by a group of typical vibrating systems. Representation of simple harmonic motion. Combination of several simultaneous motions. Simple cases of free and forced vibrations, with damping. Resonance. Principles of transmission and isolation of vibration. Systems of variable mass and variable elasticity. Vibrations of taut wires, bars, beams, rings, membranes, and plates. Relation of vibration and noise. Detection and measuring instruments. Examples of diagnosis and preventive measures. Professor GOODIER. (Given only in alternate years. To be given in 1942–43.)

3M59. *Seminar in Applied Mechanics*. Elective for graduates (undergraduates by special permission). Either or both terms. Credit, one hour each term. One discussion period each week. Prerequisites 3M56 and 3M57 or equivalents. Current research papers in applied mechanics reported and discussed by members of the group. Professor GOODIER.

3M60. *Theory of Elastic Stability*. Elective for seniors and graduates. First term. Credit three hours. Prerequisite course 3M22a, b, 3M24, or equivalents. Mathematical analysis of the conditions under which columns, beams, rings, tubes, thin plates, and thin curved shells may fail by general or local buckling. Applications to mechanical, civil, naval, and aeronautical structures. Professor GOODIER. (Given only in alternate years. Not given in 1942–43.)

3M61. *Advanced Fluid Mechanics*. Elective for seniors and graduates. Second term. Credit three hours. Prerequisite courses 3M23 or 33, 3M24, or equivalents. The study of various fluid phenomena, modern methods of rational analysis being correlated with empiricism and research; dimensional analysis; elementary principles of flow; generalized equations; irrotational motion, conformal mapping, fundamental equations of viscous flow; fluid turbulence; boundary layer phenomena; flow around immersed bodies; flow in closed conduits; flow in open channels; wave phenomena. Professor GOODIER and Mr. KOCH.

HEAT-POWER ENGINEERING (P)

3P31, 3P32. *Heat-Power Engineering.* Required of all juniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite courses, Physics 21 and 22 and 3D21, 3D23, 3D24, 3M21, 3M22a and b. Three recitations a week throughout the year. Thermodynamics of gases and vapors; ideal cycles and their application in air compressors, internal combustion motors, steam engines, turbines, and power plants; actual machines; efficiencies and performances; study of engine and turbine losses and the usual means of reducing them; compound, uniflow, and other types of steam engines; types of air compressors, internal combustion engines; steam turbines; air-vapor mixtures; and heat transfer. On account of the importance of a thorough understanding of this subject, the student is required to solve a large number of problems in the classroom. Assistant Professor CLARK.

3P33, 3P34. *Heat-Power Engineering.* Required of juniors in Electrical Engineering, Chemical Engineering, and Administrative Engineering. Not open to students in Mechanical Engineering. Throughout the year. Credit three hours a term. Three periods a week. Prerequisite courses 3D25, 3D26, 3M21, 3M22a. The course is an abridged treatment of substantially the same ground as courses 3P31, 3P32, and 3P41, 3P42; it is supplemented in the senior year by course 3P54. The longer courses 3P31, 3P32, and 3P41, 3P42 may be substituted for this one. Associate Professor HOOK and Messrs. WRIGHT, CONTA, and GAY.

3P41, 3P42. *Heat-Power Engineering.* Required of all seniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite course 3P31, 3P32. Three periods a week. An extension of course 3P31, 3P32. Engine and turbine types; steam turbine theory, development of present forms, performance, economy, suitability for particular service; fuels and fuel resources; combustion, ideal and in the actual furnace and engine; steam-generating units and their performance; furnaces, boilers, superheaters, economizers, and air preheaters; exit losses; draft; flow of fluids in pipes; feed water heaters, condensers, cooling towers and other apparatus; feed water treatment; consideration of the economical combination of elements in power plants. Basic elements of refrigeration. Professor ELLENWOOD and Messrs. CONTA and GAY.

3P43. *Heat-Power Equipment.* Required of all seniors in Civil Engineering. Second term. Credit three hours. Not open to students in Mechanical or Electrical Engineering. Prerequisite courses, Physics 11 and 12 (or the equivalent), Chemistry 106a, b, C.E. 220 and 221. Basic consideration of the behavior of gases and vapors as applied to heat engines; also the operation, maintenance, application, performance, first cost, and operating cost of air compressors, compressed air equipment, internal-combustion engines of both the carburetor and the compression-ignition types, steam boilers, engines, and turbines. This course is recommended for all students who wish to obtain a general basic knowledge of the usual types of heat engines with special attention given to those which are most commonly used by the civil engineer. Two lectures and one two-hour period used for laboratory, inspection, computing, or quiz purposes. *West Sibley.* Professor ELLENWOOD and Mr. GAY.

3P43A. *Heat-Power Engineering.* This course is given for U. S. Army engineers taking graduate work at Cornell. Two lectures and one laboratory period a week. Second term. The work will deal chiefly with the operation,

performance characteristics, first cost, and operating cost of spark-ignition engines, compression-ignition engines, steam turbines, steam engines, steam boilers, air compressors, and pumps. Inspection trips are also required. Professors ELLENWOOD and DAVIS.

3P44, 3P45. *Steam and Oil-Engine Power Plants.* Required of Mechanical Engineering seniors in Option A. Two lectures a week throughout the year. Credit two hours a term. Prerequisite courses 3D31, 3D32, 3D33, 3P31, and 3P32; must be accompanied by courses 3P46 and 3P47, and accompanied or preceded by courses 3P41 and 3P42. Performance characteristics and design features of steam prime movers, steam generators, condensers, feedwater heaters, evaporators, deaerators, oil engines, pumps, fans, and cooling towers; power-plant piping; automatic control; power-plant instruments, fuel-burning equipment; coal-and ash-handling equipment. Mr. WRIGHT.

3P46, 3P47. *Power Plant Computing and Design.* Required of Mechanical Engineering seniors in Option A. Two computing periods a week throughout the year. Credit two hours a term. Must be accompanied by 3P44 and 3P45. Energy balances; plant layouts; piping layouts; selection of equipment for central stations and industrial power plants. Mr. WRIGHT.

3P48. *Heating, Ventilating, and Air Conditioning.* Required of all seniors in Mechanical Engineering except those electing Option B. Either term. Credit three hours. Principles and practice in the conditioning of air, including cooling, heating, dehumidifying, and ventilating. Professor MACKEY.

3P49. *Refrigeration.* Elective for seniors. Required in Option B. First term. Credit two hours. Prerequisite course 3P32 or 3P34. Two lectures or recitations a week. A course dealing with the general principles, applications, and economic and commercial factors involved in various forms of modern refrigeration as applied to both domestic and industrial installations, including those pertaining to air conditioning. Professor ELLENWOOD.

3P50. *Power Plant Economics; Equipment Selection.* Elective for seniors. First term. Credit two hours. Prerequisite courses 3P31, 3P32 or 3P33, 3P34. Two lectures a week. Cost of equipment and plants; energy costs; load curves, station factors; determining characteristics of equipment: selection of working pressures and temperatures and cycles; proper load distribution; economic number and size of units; selection of equipment based on these and other determining considerations; economic operation. Applications to central stations and to industrial power and heating plants. Other similar topics. Mr. WRIGHT.

3P51. *Steam Turbines.* Elective for seniors. Second term. Credit two hours. Prerequisite courses 3P31, 3P32, or 3P33, 3P34. Two lectures a week. Classification of turbines and description of leading features of the various types; mechanical and thermal considerations underlying the action of steam in turbines; calculations involved in turbine design; discussion of building, erecting, and testing; adaptability to special conditions of service; economic results of the use of turbines in engineering practice. Assistant Professor CLARK.

3P52. *Internal Combustion Engines.* Elective for seniors. First term. Credit two hours. Prerequisite courses 3D31, 3D32, 3D33 and 3P31, 3P32 or 3P33, 3P34. Two periods a week. Seminar. Reports and discussions. Fuels; general theory and salient points in the design and operation of internal combustion

engines; study of existing commercial types, relative advantages, and questions of economy; current developments. Assistant Professor CLARK.

3P53. *Steam Boilers and Related Apparatus.* Elective for seniors. First term. Credit two hours. Prerequisite courses 3D31, 3D32, 3D33, and 3P31, 3P32 or 3P33, 3P34. Two periods a week. Fuels, combustion, combustion apparatus; furnace and boiler types, proportions, materials, design of details; superheaters, economizers, air heaters; accessories; equipment, arrangement, and operation of steam-generating plants. Associate Professor HOOK.

3P54. *Heat-Power Engineering.* Required of A.E. seniors. Elective for E.E. seniors. Not open to M.E. students. Second term. Credit two hours. Two lectures a week. A continuation of courses 3P33, 3P34. Associate Professor HOOK.

3P55. *Graphical Computation and Representation.* Elective for all except freshmen. First term. Credit two hours. Slide rules; construction of net work charts and alignment charts for the solution of equations; and derivation of empirical equations from experimental curve. Professor MACKEY.

3P57, 3P58. *Heat Engineering.* Throughout the year. M.E. seniors in Option B. Credit four hours a term. Must be accompanied or preceded by 3P41, 3P42, and 3P49. Properties of mixtures, dimensional analysis, fluid flow, heat transmission, selection of fans and pumps, and refrigeration; applications to problems in air conditioning. Professor MACKEY.

3P61, 3P62. *Advanced Heat-Power Engineering.* Elective for graduate students and seniors. Throughout the year. Credit two hours a term. Two recitations a week. Consideration of advanced problems dealing with internal-combustion-engine and steam-power plants. Professor ELLENWOOD.

3P63. *Advanced Thermodynamics.* Elective for seniors and graduate students. Second term. Credit two hours. Two recitations a week. Prerequisite, permission of instructor. The Carnot Principle; temperature scales; entropy; the state properties of a substance, their experimental determination and correlation; equations of state; kinetic theory of gases; mixtures of ideal gases; special topics in mathematics will be considered as needed. Mr. WRIGHT.

3P70. *Advanced Heat-Power Engineering Research.* Elective for graduate students and others qualified for advanced study in this field. Work and credit as arranged with Professors ELLENWOOD and MACKEY and other members of the department.

MATERIALS PROCESSING (S)

3S11. *Metal Working.* Freshmen. Credit one hour. Either term. One 2½-hour period a week. Hot-working processes and methods of joining: demonstrations and discussions of rolling, extrusion, drawing, and forging methods; practice in hand forging, forge welding, hardening and tempering; demonstrations followed by practice in oxy-acetylene welding and cutting, atomic hydrogen and electric welding. Also a study of mechanical fastenings. (This course may be substituted for former course 103—Introductory Laboratory.) Assistant Professors CARRUTHERS and Messrs. HILL and MACK.

3S14. *Casting Processes.* Freshmen in Electrical Engineering. Credit one hour. Either term. One 2½-hour period a week. Coordinated instruction in foundry practice and pattern design and construction. Survey of casting methods including demonstrations of die casting and permanent mold cast-

ing. Practice in sand molding and core making followed by instruction in the design and practice in making patterns. (This course may be substituted for former course 102, Woodshop, or for 3S21, Pattern Shop.) Assistant Professor CARRUTHERS and Messrs. PATTERSON, CURTIS, and YAWGER.

3S15. *Casting Processes.* Freshmen in Mechanical Engineering. Credit two hours. Either term. Two 2½-hour periods a week. Includes all of course 3S14 and the following: study of sands, sand testing, and sand handling, machine molding, cupola and electric furnace operation, non-ferrous melting and founding, and study of continuous systems in production. Assistant Professor CARRUTHERS and Messrs. PATTERSON, CURTIS, and YAWGER.

3S16. *Casting Processes.* Credit one hour. Either term. One 2½-hour period a week. For students who have completed 3S14, or the equivalent, and desire to have the additional instruction offered in 3S15. (This course may be substituted for former course 3S22, Foundry.) Assistant Professor CARRUTHERS and others.

3S23. *Machine Tool Processes.* Required of M.E., E.E., and A.E. sophomores. Credit two hours. Either term. Two 2½-hour periods a week. Prerequisite courses: 3S11 and 3S14 or 3S15. Fundamentals of machine tools and cutting tools. Study of machine tool design as related to modern tools and methods. Demonstrations and practice of the basic operations including gear-cutting methods. Operation and use of jigs and other manufacturing fixtures. Demonstrations and study of cold rolling, drawing, spinning, and punch and die operations. Plastics. (This course may be substituted for former course 3S32, Machine Shop.) Assistant Professor CARRUTHERS and Messrs. GEER and GREEN.

3S24. *Measuring Instruments.* Required of M.E. sophomores. Credit one hour. One 2½-hour period a week. Prerequisite courses: 3S11, and 3S14 or 3S15. Must be accompanied by or preceded by 3S23. Study of types of gauges and measuring instruments and their applications; jigs, fixtures, and demonstrations of their use. (Courses 3S23 and 3S24 may be substituted for former course 3S31, Machine Shop.) Assistant Professor CARRUTHERS and Mr. GEER.

3S50. *Advanced Materials Processing.* Work and credit as arranged with Assistant Professor CARRUTHERS.

EXPERIMENTAL MECHANICAL ENGINEERING (X)

3X21. *Materials of Engineering.* Required of M.E., E.E., A.E. in M.E., and A.E. in E.E. sophomores. First term. Credit 3 hours. Prerequisite: Chemistry 102a and b, or equivalent. An elementary lecture course in engineering materials covering the metallurgy of iron and steel, the constitution of metals and alloys, and the metallography of iron and steel. Assistant Professor JEFFREY.

3X22. *Materials of Engineering.* Required of M.E. and A.E. in M.E. sophomores. Second term. Credit 3 hours. Prerequisite: 3X21. A continuation of Course 3X21, with lectures covering the metallography of the alloy steels, non-ferrous metals and alloys, corrosion, fuels and their combustion, refractories, cementing materials, wood, rubber, plastics, etc., and the testing and inspection of materials. Assistant Professor JEFFREY.

3X31. *Materials Testing and Physical Metallurgy.* Required of M.E. juniors.

First term. Credit 4 hours. Prerequisite courses 3X21, 3X22, or their equivalent, and 3M21 and 3M22a. A laboratory course dealing with the determination of physical and mechanical properties of materials (principally metals and alloys) by means of various tests; a study of the behavior of materials in different kinds of loading; the selection of materials for a given use based upon the properties; the control of physical and mechanical properties of ferrous and non-ferrous alloys by various forms of thermal and mechanical treatments, with emphasis on the relationship between the phase changes, the microstructure, and properties. A written report is required on each experiment. Professor DAVIS, Assistant Professors JEFFREY and MOYNIHAN, and Messrs. CONTA, OTTO, EHRHART, WATSON, and H. J. KING.

3X32. *Mechanical Laboratory—Experimental Engineering.* Credit three hours. Second term. M.E., E.E., A.E. juniors. Prerequisite courses: 3X21, 3M23 or 3M33, 3P31 or 3P33, 3P32 or 3P34. All of these courses must either have been completed or be taken concurrently with 3X32. A laboratory course dealing with the calibration and use of engineering instruments; the properties of oils; principles of lubrication; solid, liquid, and gaseous fuel analysis and calorimetry; fundamentals of fluid flow; steam engine performance and characteristics; internal combustion engine performance and combustion characteristics. A written report is required on each experiment. Professor DAVIS, Assistant Professors MOYNIHAN and JEFFREY, and Messrs. CONTA, OTTO, EHRHART, WATSON, and H. J. KING.

3X33. *Materials Testing and Physical Metallurgy.* E.E. and A.E. juniors, and fourth year students in Chemical Engineering. First term. Credit 3 hours. Prerequisites 3X21 and 3M21 and 3M22a. This course is an abridgment of Course 3X31. Professor DAVIS, Assistant Professors JEFFREY and MOYNIHAN, and Messrs. CONTA, OTTO, EHRHART, WATSON, and H. J. KING.

3X34. *Mechanical Laboratory—Experimental Engineering.* Required of fourth year students in Chemical Engineering. Credit three hours. Prerequisite courses 3X21 or its equivalent, 3M23, 3P33, and 3P34. All of these courses must either have been completed or be taken concurrently with 3X34. A laboratory course dealing with principles of lubrication; fundamentals of fluid flow; heat transmission; steam engine performance and characteristics; internal combustion engine performance; combustion characteristics of fuels; air flow; centrifugal blower; centrifugal pump; air compressor; refrigeration. A written report is required on each experiment. Professors DAVIS and GAGE, Assistant Professors ANDRAE, JEFFREY, and MOYNIHAN.

3X41. *Mechanical Laboratory—Experimental Engineering.* For seniors in Mechanical Engineering and Administrative Engineering in M.E. First term. Credit four hours. Prerequisite courses 3X32, 3P31 or 3P33, 3P32 or 3P34 and 3M23 or 3M33. A laboratory course with comprehensive tests of steam power plant equipment and apparatus, boilers, engines, turbines; internal combustion engines, Diesel and gasoline; hydraulic turbines, reaction and impulse; centrifugal pumps and blowers; air-conditioning. A written report is required on each experiment. Professors GAGE and SAWDON. Assistant Professors ANDRAE, ERDMAN, and FAIRCHILD.

3X42. *Mechanical Laboratory—Experimental Engineering.* For seniors in Mechanical Engineering and Administrative Engineering in M.E. Second term. Credit four hours. A continuation of 3X41, with more detailed study

of the tests and testing methods. Studies are made of the testing and performance of apparatus listed under 3X41 as well as a two stage air compressor, a refrigerating plant, a high-speed engine indicator (cathode ray oscillograph type), a demonstration wind tunnel, and means of measuring the rate of flow of water and air. Uusually the laboratory work is followed by a discussion and computing period. Reports required as in 3X41. Professor GAGE and SAWDON, Assistant Professors ANDRAE, ERDMAN, and FAIRCHILD.

3X43. *Mechanical Laboratory—Experimental Engineering.* Required of seniors registered in the Mechanical Option in Electrical Engineering and Administrative Engineering in E.E. First term. Credit two hours. Prerequisite courses 3X32, 3P33, and 3P34. Experiments selected by the faculty from course 3X41. Professors GAGE and SAWDON, Assistant Professors ANDRAE, ERDMAN, and FAIRCHILD.

3X51. *Experimental Engineering Research.* Elective. Either or both terms. Credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have available at least two laboratory periods a week and who have shown proficiency in engineering subjects. Special problems and investigations which are in general carried on in the laboratories under the immediate direction of the members of this department. Professors DAVIS, SAWDON, and GAGE, Assistant Professors ANDRAE, JEFFREY, and MOYNIHAN, and representatives of the department in which the student is taking his major work.

3X52. *Applied Metallography.* Elective. First term. Credit two hours. Prerequisite course 3X31. Covers in historical sequence the development of knowledge of the internal structure of metals, and the relation of structure and properties; the technique of metallographic research, study of application of the laws of physical chemistry to interpretation and correlation of results. Study of stable and metastable conditions; heat treatment theory and practice. The practical aim of metallography is constantly emphasized. Professor UPTON.

3X53. *Temperature Measuring Instruments.* Elective for seniors and graduates. Either term. Credit two hours. One $2\frac{1}{2}$-hour laboratory-lecture period each week. Prerequisite courses, 3X32 or 3X34. Theory, construction, calibration, and application of: liquid-in-glass thermometers, solid expansion thermometers, pressure-spring thermometers, electrical resistance thermometers, thermocouples, optical pyrometers and radiation pyrometers. Dr. DROPKIN.

Also see courses listed in Option G, Metallurgical Engineering (page 106) and those under Chemistry and Chemical Engineering on pages 110–161.

School of Electrical Engineering

THE COURSES OF STUDY

The School of Electrical Engineering offers regular courses of study leading to the degree of Bachelor of Electrical Engineering or to that of Bachelor of Science in Administrative Engineering, specializing in Electrical Engineering. A five-year course is offered, in which both degrees may be obtained in the five-year period. Also, a regular five-year course is offered, in which the student may receive the degree of Bachelor of Electrical Engineering at the end of the fourth year and the degree of Bachelor of Mechanical Engineering at the end of the fifth year. A five-year course may be arranged, in which the student may supplement either of the regular four-year courses with an additional year of cultural or general training. A six-year course is offered, which leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Bachelor of Electrical Engineering or of Bachelor of Science in Administrative Engineering at the end of the sixth year.

The Freshman year for the regular four-year and five-year courses is described below. Information regarding the later years, the alternative courses, and the options and electives will be found on the following pages.

THE FRESHMAN YEAR

Freshmen in the School of Electrical Engineering have the same schedule of courses, whether registered in the course leading to the degree of Bachelor of Electrical Engineering or in that leading to the degree of Bachelor of Science in Administrative Engineering. This schedule is similar to that of Freshmen in the School of Mechanical Engineering, so that a change between these two schools may be accomplished without serious complication if made before the student starts his second year. The Freshman schedules in the Schools of Civil and Chemical Engineering differ somewhat from that of Electrical Engineering, so that a change to or from one of these schools cannot be made without loss of time, requiring either a longer time to obtain the degree or attendance at one or more summer sessions.

The schedule for the Freshman year in Electrical Engineering is as follows:

FIRST YEAR
37 HOURS

	HOURS *First Term*	HOURS *Second Term*
Analytic Geometry and Calculus, Mathematics 55a, 55b	5	5
General Physics 11, 12	4	4
General Chemistry 102 or 104	3	3
Drawing and Descriptive Geometry 3C11	3	0
Mechanical Drafting 3C12	0	3
Metal Working 3S11	1 or 0	0 or 1
Casting Processes 3S14	0 or 1	1 or 0
Introductory Lectures 4G11	1	0
Introductory Electrical Practice 4G14	0	1
Elementary Surveying 210A	0	1
Hygiene 1, 2	1	1

In addition to the courses in the above schedule, all Freshmen must satisfy the University's requirement in Military Science and Tactics. (See the *General Information Number.*)

A student intending to take the five-year course leading to both the B.E.E. and the B.M.E. degrees should take Casting Processes 3S15, 2 hours, instead of Casting Processes 3S14, 1 hour, during the first term.

Four-Year Course (B.E.E.)

The regular four-year course of study in the School of Electrical Engineering, leading to the degree of Bachelor of Electrical Engineering, is outlined below.

		HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	See page 137	18	19
SECOND YEAR 38 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Hydraulics 3M23	0	2
	Physics P21, P22	3	3
	Kinematics, Recitations 3D25	3	0
	Kinematics, Drawing 3D26	2	0
	Materials of Engineering 3X21	3	0
	Industrial Organization and Management 3A35a	3	0
	Elements of Electrical Engineering 410	0	4
	Engineering Mathematics 480	0	2
	Machine Tool Processes 3S23	0	2
	English 2 or Public Speaking 1	0	3
	In addition to the courses in the above schedule, all sophomores must satisfy the University's requirement in Military Science and Tactics. (See the *General Information Number.*)		
THIRD YEAR 37 HOURS	Elements of Electrical Engineering 411, 412	3	4
	Direct Current Machinery 413	2	0
	Electrical Engineering Laboratory 431, 432	3	2
	Engineering Mathematics 481	2	0
	Electronics 450	0	4
	Heat Power 3P33, 3P34	3	3
	Mechanical Laboratory 3X33, 3X32	3	3
	Machine Design, Recitations 3D34	2	0
	Economic Organization 3A21	0	3
FOURTH YEAR 37 HOURS	Electrical Engineering Practice, 421, 422	3	3
	Electrical Engineering Theory, 423, 424	2	2
	Electrical Engineering Laboratory 433, 434	4	4
	Non-Resident Lectures 4G41	0	1
	Electrical Engineering Options (See page 139)	3 or 6	6 or 3
	Mechanical or Civil Elective (See below)	2	0
	Elective	4 or 1	3 or 6

Grand Total for the Four-Year Course ..... 149 hours

Mechanical or Civil Elective

Senior students of Electrical Engineering, or of Administrative Engineering specializing in Electrical Engineering, have the choice of a course in Mechanical Engineering or in Civil Engineering, namely, Mechanical Laboratory, 3X43, 2 hours, or Elements of Structural Engineering, 279, 2 hours. These courses are described in the sections devoted to the respective schools.

Electrical Engineering Options

Seniors in Electrical Engineering may select one of the following options: (1) Electric Power and Design, (2) Electric Communications. Under the option selected, the student must take at least nine hours.

ELECTRIC POWER AND DESIGN OPTION

Electric Power Plant Design	441	3 hours
Electrical Design	442	4 "
Economics of Public Utilities	444	3 "
Electric Transmission & Distribution	463	3 "
Industrial Application & Control	462	2 "

ELECTRIC COMMUNICATION OPTION

Electrical Communication Engineering	451, 452	7 "
Theory of Communication Networks	453, 454	4 "
Ultra High Frequency Techniques	4C53, 4C54	6 "

By special permission of the Electrical Engineering Faculty a qualified student may take some other grouping of related courses to meet the option requirements. However, the student must show that the combination of courses desired has a definite purpose and will provide a well-rounded program in the chosen field of specialization.

The student taking the five-year course for both B.E.E. and B.M.E. degrees takes at least three hours of the option during the fourth year and the remaining hours during the fifth year.

OPTIONS IN SCIENCES

A student who has completed the first two years of the regular four-year course with a satisfactory record and with excellent grades in Mathematics, Physics, and Mechanics, may, if his class adviser approves, substitute a group of courses in Physics (or in another science such as Mathematics, Chemistry, or Economics) for certain courses of instruction normally required in the Junior and Senior years, namely, Machine Design 3D34, two hours, Economic Organization 3A21, three hours, and Mechanical or Civil elective, two hours. Such a substitution is permitted only after the student has made full use of his elective hours. Permission to continue in any of these options may be withdrawn at any time if the student's work is not satisfactory. A five-year Engineering-Physics Program can be arranged similar to that for Mechanical Engineering students. See page 111.

Four-Year Course (B.S. in A.E.)

The regular course of study in the School of Electrical Engineering, leading to the degree of Bachelor of Science in Administrative Engineering, is described below. The significant feature of this course is its coordination of technical instruction with instruction in associated industrial business functions.

		HOURS	
		First Term	*Second Term*
FIRST YEAR 37 HOURS	See page 137	19	18
SECOND YEAR 39 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Hydraulics 3M23	0	2
	Physics P21	3	0
	Kinematics, Recitations 3D25	3	0
	Kinematics, Drawing 3D26	2	0
	Materials of Engineering 3X21	3	0
	Elementary Industrial Statistics 3A41	3	0
	Elements of Electrical Engineering 410	0	4
	Engineering Mathematics 480	0	2
	Business and Industrial Management 3A23	0	4
	English 2	0	3
	Technical Writing 3A33	0	2
	In addition to the courses in the above schedule, all sophomores must satisfy the University's requirement in Military Science and Tactics or in Physical Training. (See the *General Information Number.*)		
THIRD YEAR 38 HOURS	Electrical Engineering 411, 412	3	4
	Direct Current Machinery 413	2	0
	Electrical Engineering Laboratory 431, 432	3	2
	Electronics 450	0	4
	Heat Power 3P33, 3P34	3	3
	Mechanical Laboratory 3X33, 3X32	3	3
	Machine Design, Recitations, 3D34	2	0
	Principles of Industrial Accounting and Cost Finding 3A31	3	0
	Economic Organization 3A21	0	3
FOURTH YEAR 37 HOURS	Electrical Engineering 403, 404	2	2
	Electrical Engineering Laboratory 437, 438	2	2
	Industrial Relations 3A49	2	0
	Industrial Marketing 3A44	3	0
	Money and Banking, Economics 11	3	0
	Business Law 3A43, 3A46	3	2
	Principles of Cost Control 3A47	0	3
	Corporation Finance 3A34	0	3
	Public Speaking 1	0	3
	Non-Resident Lectures 4G41	0	1
	Mechanical or Civil Elective (See page 138)	2	0
	Electives	0	4

Grand total for the Four-Year Course ..... 151 hours

A Five-Year Course (B.E.E. and B.S. in A.E.)

In the four-year course leading to the degree of Bachelor of Science in Administrative Engineering some of the technical courses in electrical engineering must be abridged to provide time in the curriculum for the courses in industrial business functions. To meet the needs of those students who desire both the complete technical training of the regular four-year course in electrical engineering and the broader business training of the administrative engineering course, a combined five-year program has been arranged, leading to the degree of Bachelor of Electrical Engineering at the end of four years, and Bachelor of Science in Administrative Engineering at the end of the fifth year. Students registered in either of the regular four-year courses, in electrical engineering or in administrative engineering, specializing in electrical engineering, may change to this course at the beginning of the sophomore year. The change may be made as late as the beginning of the junior year without serious difficulty, although attendance at one summer school would normally be required, in order to adjust differences in the courses. An outline of the course follows:

		HOURS	
		First Term	*Second Term*
FIRST YEAR 37 HOURS	See page 137	18	19
SECOND YEAR 38 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Hydraulics 3M23	0	2
	Physics P21, P22	3	3
	Kinematics, Recitations 3D25	3	0
	Kinematics, Drawing 3D26	2	0
	Materials of Engineering 3X21	3	0
	Elementary Industrial Statistics 3A41	3	0
	Elements of Electrical Engineering 410	0	4
	Engineering Mathematics 480	0	2
	Machine Tool Processes 3S23	0	2
	English 2	0	3
	In addition to the courses in the above schedule, all sophomores must satisfy the University's requirement in Military Science and Tactics. (See the *General Information Number.*)		
THIRD YEAR 38 HOURS	Elements of Electrical Engineering 411, 412	3	4
	Direct Current Machinery 413	2	0
	Electrical Engineering Laboratory 431, 432	3	2
	Engineering Mathematics 481	2	0
	Electronics 450	0	4
	Heat Power 3P33, 3P34	3	3
	Mechanical Laboratory 3X33, 3X32	3	3
	Technical Writing 3A33	2	0
	Business and Industrial Management 3A23	0	4

FOURTH YEAR 38 HOURS	Electrical Engineering Practice 421, 422	3	3
	Electrical Engineering Theory 423, 424	2	2
	Electrical Engineering Laboratory 433, 434	4	4
	Non-Resident Lectures 4G41	0	1
	Electrical Engineering Option (See page 139)	3 or 6	6 or 3
	Mechanical or Civil Elective (See page 138)	2	0
	Machine Design, Recitations 3D34	2	0
	Economic Organization 3A21	3 or 0	0 or 3
	Principles of Industrial Accounting and Cost Finding 3A31	3 or 0	0 or 3
	Grand total for the B.E.E. degree		151 hours
FIFTH YEAR 36 HOURS	Industrial Relations 3A49	2	0
	Industrial Marketing 3A44	3	0
	Money and Banking Ec11	3	0
	Business Law 3A43, 3A46	3	2
	Principles of Cost Control 3A47	0	3
	Corporation Finance 3A34	0	3
	Public Speaking 1	0	3
	Electives	7	7
	Grand total for the B.E.E. and B.S. in A.E. degrees		187 hours

A Five-Year Course (B.E.E. and B.M.E.)

In various fields of practice and investigation the electrical engineer may require more instruction in heat-power engineering, hydraulic-power engineering, mechanics, experimental engineering, and other phases of mechanical engineering than can be given in a regular four-year course in electrical engineering; similarly, the mechanical engineer often has use for a more extensive training in electrical engineering than can be included in a four-year course in mechanical engineering. To meet these broader requirements a five-year course of study is offered, leading to the degree of B.E.E. at the end of four years of study and the degree of B.M.E. at the end of the fifth year. To complete the program outlined in five years, certain of the shop courses must normally be taken in the summer, usually in the short sessions immediately following or preceding the regular academic year.

		HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 38 HOURS	See page 137	19	19
SECOND YEAR 38 HOURS	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Strength of Materials 3M22b	0	2
	Physics P21, P22	3	3
	Kinematics, Recitations 3D21	2	0
	Kinematics, Drawing 3D23	2	0
	Kinematics, Recitation and Drawing 3D24	0	3
	Materials of Engineering 3X21, 3X22	3	3
	Industrial Organization and Management 3A35a	3	0
	Elements of Electrical Engineering 410	0	4
	Engineering Mathematics 480	0	2

In addition to the courses in the foregoing schedule, all sophomores must satisfy the University's requirement in Military Science and Tactics. (See the *General Information Number.*)

SHORT SESSION	Machine Tool Processes 3S23		2
THIRD YEAR 38 HOURS	Elements of Electrical Engineering 411, 412	3	4
	Direct Current Machinery 413	2	0
	Electrical Engineering Laboratory 431, 432	3	2
	Engineering Mathematics 481	2	0
	Electronics 450	0	4
	Heat Power 3P31, 3P32	3	3
	Machine Design, Recitations 3D31a, 3D32a	3	2
	Machine Design 3D33a	0	2
	Fluid Mechanics 3M33	4	0
	Measuring Instruments 3S24	0	1
FOURTH YEAR 37 HOURS	Electrical Engineering Practice 421, 422	3	3
	Electrical Engineering Theory 423, 424	2	2
	Electrical Engineering Laboratory 433, 434	4	4
	Mechanical Laboratory 3X31, 3X32	4	3
	English 2	3 or 0	0 or 3
	Economic Organization 3A21	0	3
	Electrical Engineering Option (See page 139)	0 or 3	3 or 0
	Civil Elective (See page 139)	2	0
	Non-Resident Lectures 4G41	0	1
	Grand total for B.E.E. Degree		153 hours
FIFTH YEAR 37 HOURS	Heat-Power Engineering 3P41, 3P42	3	3
	Mechanical Laboratory 3X41, 3X42	4	4
	Principles of Industrial Accounting and Cost Finding 3A31	3	0
	Heating, Ventilating, and Air Conditioning 3P48	0	3
	Electrical Engineering Option (See page 139)	3	3
	Mechanical Engineering Option (See page 138) / Electives (See page 45)	6	5
	Grand total for B.E.E. and B.M.E. Degrees		190 hours

A Five-Year Course (B.E.E. or B.S. in A.E.)

A five-year course leading to the degree of Bachelor of Electrical Engineering or of Bachelor of Science in Administrative Engineering, specializing in Electrical Engineering, may be arranged to include all the work of one of the regular four-year courses outlined above, and, in addition, the equivalent of one year of work in other studies, generally in the College of Arts and Sciences, designed to broaden the student's training. There is no fixed schedule for such a program, since much depends upon the student's special interests. Advice and assistance in arranging such a schedule may be obtained by applying to the Director of the School.

A Six-Year Course (A.B. and B.E.E.)

To meet the requirements for a broad liberal training combined with a specialized course in engineering, a six-year course has been arranged, leading to the Bachelor of Arts degree at the end of four years and the Bachelor of Electrical Engineering degree at the end of the sixth year. A student taking this course is registered during the first four years in the College of Arts and Sciences and must conform to the requirements of that college regarding admission and course of study. However, in order to complete the program in the six-year period, he must complete the freshman engineering subjects, or their equivalent, before beginning the fourth year and the sophomore engineering subjects, or their equivalent, before beginning his fifth year. Advice and assistance in arranging the six-year program may be obtained by applying to the Director of the School of Electrical Engineering and to the Dean of the College of Arts and Sciences.

As a suggestion, the following schedule is outlined to provide a broad scientific training in the physical sciences and mathematics before taking the professional engineering courses. It is assumed that the student has offered the equivalent of Mathematics 15 and of either Mathematics 5 or Mathematics 10 for entrance.

		HOURS	
		First Term	*Second Term*
FIRST YEAR 33 HOURS	English 2	3	3
	Foreign Language (preferably German or French)	3	3
	History	3	3
	Mathematics 5 or 10 (unless both are offered for entrance)	3	0
	Mathematics 60a, 60b	3	3
	Geology 100	0	3
	Hygiene 1, 2	1	1
	Introductory Engineering Lectures 4G11	1	0
	In addition to the courses in the above schedule the student must satisfy the University's requirement in Military Science and Tactics. (See the *General Information Number.*)		
SECOND YEAR 36 HOURS	Foreign Language	3	3
	Mathematics 60c, 60d	3	3
	Chemistry 102 or 104	3	3
	Physics 11, 12	4	4
	Drawing and Descriptive Geometry 3C11	3	0
	Mechanical Drafting 3C12	0	3
	Metal Working 3S11	1	0
	Casting Processes 3S14	1	0
	Introductory Electrical Practice 4G14	0	1
	Elementary Surveying 210A	0	1
	Military Training (See note above)		

THIRD YEAR 34 HOURS	Mathematics 130	3	0
	Mathematics 200	0	3
	Physics 60	3	3
	Physics 61, 62	3	3
	Kinematics, Recitations 3D25	3	0
	Kinematics, Drawing 3D26	2	0
	Materials of Engineering 3X21	3	0
	Industrial Organization and Management 3A35a	0	3
	Machine Tool Processes 3S23	0	2
	Public Speaking 1	0	3
FOURTH YEAR 35 HOURS	Mathematics 215	3	3
	Mechanics 3M21	5	0
	Strength of Materials 3M22a	0	3
	Hydraulics 3M23	0	2
	Elements of Electrical Engineering 410	0	4
	Physics 121, 122	3	3
	Physics 171	3	0
	Physics 105	0	3
	Economics 2a	3	0

(Bachelor of Arts Degree)

The student may now enter the third year of the course leading to the degree of Bachelor o Electrical Engineering. (See page 138.)

A similar schedule leading to the degree of Bachelor of Science in Administrative Engineering at the end of the sixth year may also be arranged.

Elective Courses

A student of the School of Electrical Engineering may elect any course of instruction offered by any department of the University provided he has the necessary preparation for it and also the approval of his class adviser. Not more than four hours of credit for Advanced Military Science, in addition to the Basic Courses of the freshman and sophomore years, will be given toward meeting the requirements of the B.E.E. or the B.S. in A.E. degree.

Courses of instruction given in the School of Electrical Engineering and open to election by students are indicated by title and number in the following list. The figures in the last two columns indicate the credit in hours for the first and second terms respectively.

Electric Power Plant Design 441	0	3
Electrical Design 442	0	4
Economics of Public Utilities 444	0	3
Electric Transmission and Distribution 463	3	0
Electrical Communication Engineering 451, 452	3	4
Theory of Communication Networks 453, 454	2	2
Ultra-High Frequency Techniques 4C53, 4C54	3	3
Industrial Application and Control of Electricity 462	0	2
Illumination 465, 466	2	2
Heaviside's Operational Analysis 485, 486	3	3
Patents 489	1	0
Special Electrical Engineering Problems 483, 484	1 to 3	1 to 3
A. I. E. E. Seminar 497, 498	1	1

The following list of courses given in other schools and colleges is suggested.

Advanced Hydraulics, CE 241	0	3
Hydraulic Measurements, CE 242	3	0
Foundations, CE 281	0 or 3	3 or 0
Engineering Law, CE 290	0 or 3	3 or 0
Elementary Differential Equations, Mathematics 200	0 or 3	3 or 0
Advanced Calculus, Mathematics 215	3	3
Introductory Qualitative Analysis, Chem. 210	0 or 3	3 or 0
Introductory Quantitative Analysis, Chem. 225	0 or 3	3 or 0
Gas and Fuel Analysis, Chemistry 250	0	3
Introductory Physical Chemistry (Lect.), Chem. 405	3	3
Introductory Physical Chemistry (Lab.), Chem. 410	3	3
Introductory Chem. Microscopy (Lect. and Lab.), Chem. 530	0 or 3	3 or 0
Metallography, Chem. 545	3	0
Introductory Geology 100	3 or 0	0 or 3
Engineering Geology 501	4 or 0	0 or 4
Money and Banking, Economics 11	3 or 0	0 or 3
Industrial Hygiene 5	2	0
Modern Physics 41	2	0
Special Topics in Physics 42	0	2
Electricity and Magnetism, Physics 121, 122	3	3
Modern Topics in Physics, Physics 171	3	0
Personnel Management in Industry 3A42	2	0
Principles of Industrial Accounting and Cost Finding 3A31	3 or 0	0 or 3
Principles of Cost Control 3A47	0	3
Business and Industrial Problems 3A48	0	2
Elementary Psychology 1	3 or 0	0 or 3
Psychotechnology in Business and Industry, Psychology 7b	0	3
Advanced Military Science and Tactics (See page 163)	1	1

The Courses of Instruction

The following list of courses of instruction includes the required courses for students in the School of Electrical Engineering, and also all courses offered by the School of Electrical Engineering for students in the College of Engineering. Courses in Mathematics, Chemistry, Physics, Economics, English, and Public Speaking, offered by the College of Arts and Sciences, are described on pages 164–166. Courses in the College of Engineering not under the jurisdiction of one of the four schools, as well as courses in the University not under the direct supervision of any college, required of or open to engineering students, are described on pages 162–164. Courses in the Schools of Mechanical and Civil Engineering offered to Electrical Engineering students are described under the headings of the respective schools. For elective courses not included in these lists, see the announcement of the appropriate college.

CHEMISTRY

General Chemistry 102. (See page 164).
General Chemistry 104. (See page 165).

ECONOMICS

Money and Banking 11. (See page 72).

ENGLISH

English 2. Either term. Credit three hours. Sophomores in Electrical Engineering may choose between English 2 and Public Speaking 1, second term. Required of sophomores in Administrative Electrical Engineering, second term. The aim of the course is to increase the student's ability to communicate his own thought and to understand the thoughts of others. Registration arranged by class adviser. Professor SIBLEY and others.

MATHEMATICS

Analytical Geometry and Calculus 55a, 55b. (See page 165).

PHYSICS

General Physics 11, 12. (See page 165).
General Physics 21, 22. (See page 166).

PUBLIC SPEAKING

Public Speaking 1. Either term. Credit three hours. Sophomores in Electrical Engineering may choose between English 2 and Public Speaking 1, second term. Required of seniors in Administrative Electrical Engineering, second term. For description see page 166.

CIVIL ENGINEERING

Elementary Surveying 210 A. (See page 75).
Elements of Structural Engineering 279. (See page 89).

MECHANICAL ENGINEERING

Numerous courses in the School of Mechanical Engineering are taken by students in Electrical Engineering, and the descriptions of these courses will be found in the M.E. section, above. These courses will be identified by the course number, consisting of the numeral 3 followed by a letter designating the department in which the course is given, and then by two numerals designating the course within the department.

ELECTRICAL ENGINEERING

(GENERAL COURSES)

4G11. *Introductory Lectures.* Required of freshmen in Electrical Engineering. First term. Credit one hour. One lecture each week. This course of lectures is designed to introduce the first-year men to their chosen field of engineering, and to demonstrate to them the various branches of the field. It is the purpose of the lectures to awaken the interest of the freshmen in their profession through the aid of vivid description, demonstration, and personal experience.

4G14. *Introductory Electrical Practice.* Required of freshmen in Electrical Engineering. Second term. Credit one hour. One lecture, recitation, or laboratory period each week. By means of lectures, demonstrations, and occasional laboratory or computing periods, the student is acquainted with the fundamentals of electrical machines and conductors, contacts and connec-

tions, and with electrical codes and standards. Attention is paid to the principles of engineering computations.

4G41. *Non-resident Lectures.* Required of E.E. and A.E. (in E.E.) seniors. Credit one hour each year. A series of lectures selected to acquaint seniors with the fields of engineering employment and to assist them in making the transition from college to industrial life. Notice of the lectures will be posted on the bulletin board of the School of Electrical Engineering. Credit is based largely upon attendance and the performance of special assignments by the professor in charge. Professor CHAMBERLAIN.

(TECHNICAL COURSES)

403. *Industrial Applications of Electric Power.* Required of seniors in Administrative Engineering in Electrical Engineering. First term. Credit two hours. Two recitations each week. Prerequisite courses, Electrical Engineering 412, 432, 450. A study of the principles underlying the economic application of electricity to industrial problems such as motor drives and control; electric heating and the use of electric furnaces and ovens; transportation and handling of materials; illumination and its effect on economic production. Professor CHAMBERLAIN.

404. *Economics of Public Utilities.* Credit two hours. Prerequisite course, Electrical Engineering 401. Continuation of 401 together with a study of the origin and development of public utilities, franchises, regulation and legislation, valuation, rates and rate structures, public ownership and public relations. Professor CHAMBERLAIN.

405, 406. *Fundamentals of Electrical Engineering.* Required of juniors in Administrative Engineering in Mechanical Engineering. Throughout the year. Credit four hours a term. Three recitations and a laboratory period each week. Prerequisite courses, Physics 11, 12, and Mechanics 3M21.

First term: D-C. electric and magnetic circuits; study and tests of D-C. motors, generators, and control equipment; distribution and rates; simple A-C. circuits.

Second term: A-C. circuits, measurements, and machinery; industrial applications; electronic apparatus. A study of fundamental electrical principles and machinery and the application of electrical equipment in industry. Professor CHAMBERLAIN, Associate Professor BURCKMYER, Assistant Professors MESERVE, B. K. NORTHROP, M. G. NORTHROP, and instructors.

407, 408. *Fundamentals of Electrical Engineering.* Required of fifth year students in Chemical Engineering. Throughout the year. Credit four hours a term. Three recitations and a laboratory period each week. Prerequisite courses, Physics 11, 12, 21 and Mechanics 3M21.

Similar content to courses 405, 406, but a more comprehensive treatment designed for fifth year students. Professor CHAMBERLAIN, Associate Professor BURCKMYER, Mr. JONES, and instructors.

410. *Elements of Electrical Engineering.* Required of sophomores in Electrical Engineering. Second term. Credit four hours. Prerequisite courses, Physics 11, 12, 21, Mathematics 55a and 55b, Mechanics 3M21. One lecture, two recitations, and a computing period each week. An introductory study of electrical phenomena and their application to engineering. Aims to provide

a solid foundation for further study in electrical engineering. Associate Professor STRONG and instructors.

411. *Elements of Electrical Engineering.* Required of juniors in Electrical Engineering. First term. Credit three hours. Prerequisite courses, Electrical Engineering 410 and 480. One lecture, one recitation, and one computing period each week. A thorough study of alternating current circuit fundamentals. Use of complex quantity representation. Associate Professor STRONG, Assistant Professor COTNER, and instructors.

412. *Elements of Electrical Engineering.* Required of juniors in Electrical Engineering. Second term. Credit four hours. Prerequisite course, Electrical Engineering 411, 413. One lecture, two recitations, and one computing period each week. A continuation of course 411. Application of circuit fundamentals to alternating-current machinery and equipment. Associate Professor STRONG, Assistant Professors COTNER and MESERVE.

413. *Direct Current Machinery.* Required of juniors in Electrical Engineering. Second term. Credit two hours. Prerequisite courses, Electrical Engineering 410 and 480. One lecture-recitation and one computing period each week. A study of the theory and operation of direct current machinery. Associate Professor STRONG, Assistant Professor COTNER, and instructors.

415, 416. *Principles of Electrical Engineering.* Required of juniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite courses, Physics 11, 12, 21 and Mechanics 3M21. Two lectures and one recitation-computing period each week. Electric and magnetic circuits, direct-current and alternating-current machinery. A study of the fundamental electrical principles and their practical application to industrial equipment. Emphasis is put on a quantitative study and understanding of basic electrical phenomena rather than on a survey of the characteristics and applications of currently available equipment. Associate Professor STRONG, Assistant Professor COTNER, and Drs. H. G. SMITH and SOHON.

418. *Electrical Equipment.* Required of seniors in Civil Engineering. First term. Credit three hours. Prerequisite courses, Physics 11, 12 and Mechanics, CE220, 221. Two lectures and one laboratory computing period each week. The purpose of the course is threefold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice. Professor BALLARD and instructors.

421, 422. *Electrical Practice.* Throughout the year. Credit three hours a term. Prerequisite courses 411, 412, 431 and 432. Three lecture-recitation periods each week. Practical aspects of advanced electrical theory, as applied to various types of apparatus and to some manufacturing and operating problems. Associate Professor AGER.

423, 424. *Advanced Electrical Theory.* Throughout the year. Credit two hours a term. Prerequisite courses 411, 412, 413, 431 and 432. Two recitations each week. The work of the first term covers dimensional analysis, circuits with variable characteristics, coupled circuits, non-sinusoidal currents, and Fourier series.

The second term is devoted to the balanced and unbalanced polyphase

circuits, symmetrical components, electrical transients, filter circuits, and ladder networks. This course is correlated with course 422, in which practical applications of the advanced electrical theory are considered. Associate Professor MALTI.

431. *Electrical Laboratory for E.E. Juniors.* Required of juniors in Electrical Engineering. First term. Credit three hours a term. Prerequisite courses, Mechanics 3M21, Electrical Engineering 410, and must be accompanied by 411. One recitation and one laboratory period each week. Experimental work on electrical measurements and circuits. Associate Professor BURCKMYER and Mr. J. H. SMITH.

432. *Electrical Laboratory for E.E. Juniors.* Required of juniors in Electrical Engineering. Second term. Credit two hours. Prerequisite courses, Mechanics 3M21 and Electrical Engineering 411, 413 and 431. One laboratory period each week. Experimental work on direct-current and alternating-current motors and generators and auxiliary equipment. Associate Professor BURCKMYER and Mr. J. H. SMITH.

433, 434. *Advanced Electrical Laboratory.* Required of seniors in Electrical Engineering. Credit four hours a term. Prerequisite courses, Electrical Engineering 412, 432 and 450. Two recitations, and one laboratory period each week. Laboratory technique and instrumentation. Tests on rotating machinery, transformers, and other apparatus. Associate Professor BURCKMYER and Drs. CREDLE and HUTTON.

435, 436. *Electrical Laboratory for M.E. Seniors.* Required of seniors in Mechanical Engineering. Throughout the year. Credit two hours a term. Prerequisite courses, Mechanics 3M21 and Electrical Engineering 415, 416. One recitation each week, laboratory period alternate weeks. Shorter course but similar in scope to 433 and 434. Associate Professor BURCKMYER and instructors.

437, 438. *Advanced Electrical Laboratory.* Required of seniors in Administrative Engineering in Electrical Engineering. Credit two hours a term. Prerequisite courses, Electrical Engineering 412, 432, 450. One recitation each week, and one laboratory period every other week. An abridgement of 433, 434 for Administrative Engineers. Associate Professor BURCKMYER, and instructors.

441. *Electrical Power-Plant Design.* Elective for E.E. seniors and others having the necessary preparation. Second term only. Credit three hours. Prerequisite courses 411 and 412 or equivalent. Two lecture-recitations, and one computing period each week. Selection and arrangement of the proper electrical equipment for direct and alternating current power-plants. Some attention is also devoted to operating features, and to questions of public policy and finance. Professor LEWIS.

442. *Electrical Design.* Elective for seniors in Electrical Engineering. Second term only. Credit four hours. Prerequisite courses, Electrical Engineering 421, 433. Three recitations and one computing period each week. A study of the fundamental principles underlying the design of direct- and alternating-current machinery. Assistant Professor M. G. NORTHROP.

444. *The Economics of Public Utilities.* Elective for seniors in Electrical Engineering. Second term only. Credit three hours. Three recitations each week. A study of the origin and development of public utilities, franchises, regula-

tion and legislation, valuation, rates and rate structures, public ownership and public relations. Professor CHAMBERLAIN.

450. *Electronics.* Required of juniors in Electrical Engineering. Second term. Credit four hours. Prerequisite courses 410, 411, and 431. Two lectures, one recitation, and one laboratory period each week. A study of the theory and application of electrical apparatus which involves electronic conduction in vacuum and gases with particular reference to high vacuum thermionic apparatus, gas conduction devices, photo-electric cells, mercury vapor converters and inverters, and similar equipment. Professor BALLARD and Assistant Professor B. K. NORTHROP.

451. *Electrical Communication Engineering.* Elective for seniors in Electrical Engineering. First term. Credit three hours. Two lectures, one recitation, and one laboratory or computing period each week. Prerequisite courses 411, 412, 431, and 450. Consideration of the theory of alternating currents as applied to telegraph, telephone, and radio communication. Special emphasis is placed upon the theory and the application of thermionic devices to electrical engineering. Professor BALLARD and Assistant Professor MCLEAN.

452. *Electrical Communication Engineering.* Elective for seniors in Electrical Engineering. Second term. Credit four hours. Two lectures, one recitation, and one laboratory period each week. Prerequisite courses, 450 and 451. Consideration of problems, apparatus, and measurements particularly applicable to electrical communication engineering. Professor BALLARD and Assistant Professor MCLEAN.

453, 454. *Theory of Communication Networks.* Elective for seniors in Electrical Engineering. Throughout the year. Credit two hours a term. Two recitations each week, assigned problems, and references. Must be accompanied by 451, 452. Foundation laws of elements and circuits with variable frequency. General network theorems. Two and four terminal structures. Recurrent networks and wave filters. Equalizers. Distributed circuits including continuous and concentrated loading of long lines. Special networks for very high frequencies. Assistant Professor MCLEAN.

462. *Industrial Application and Control of Electricity.* Elective for seniors and graduate students. First term. Credit two hours. Two recitations each week. A study of electric motor drive; selection of motors; study and selection of motor control; power requirements for various kinds of machinery; electric hoists, welding, heating. Professor CHAMBERLAIN.

463. *Electrical Transmission and Distribution.* Elective for seniors in Electrical Engineering. First term. Credit three hours. Two recitations and one computing period each week. This course is designed to give an understanding of the fundamentals of electric power transmission and distribution. Prerequisite courses 411, 412, 431, 450. Professor LEWIS, Assistant Professor M. G. NORTHROP, and Mr. JONES.

465, 466. *Illumination.* Elective. Throughout the year. Credit two hours a term. Open to juniors and seniors in the College of Engineering. Prerequisite courses: Physics 11, 12. A study of the production, measurement, and utilization of light with emphasis on the latter. Recitation, discussion, and problem work. Oral reports on illumination topics of current interest are a feature of the course and supplement the textbook material. Associate Professor STRONG.

480. *Engineering Mathematics.* Required of sophomores in Electrical Engineering. Second term. Credit two hours. Two recitations each week. A further study of mathematical principles, supplementing courses 55a and 55b, devoted particularly to the subjects required by the electrical engineer. The solution of equations, determinants, elementary linear differential equations, complex numbers, and dimensional analysis. Dr. SOHON.

481. *Engineering Mathematics.* Required of juniors in Electrical Engineering. First term. Credit two hours. Two recitations each week. A continuation of course 480. Fourier series, hyperbolic functions, interpolation formulas, special functions, and a continuation of differential equations. Dr. SOHON.

483, 484. *Special Electrical Engineering Problems.* Open to seniors and to qualified juniors. First or second term or both. Credit one or more hours. A course to meet the need of students who are not particularly interested in the other electives. Theoretical and experimental investigations on electrical apparatus. Each student selects his own subject, which, however, must meet with the approval of the Director of the School of Electrical Engineering. Professors and instructors as required.

485, 486. *Heaviside's Operational Analysis.* Elective for seniors and graduate students. Throughout the year. Credit three hours a term. Prerequisite courses 480, 481, or equivalent, and must either follow or be taken concurrently with 423 and 424. Two lecture-recitations and one computing period each week. Mathematical introduction covering functions of real variables, functions of complex variables, infinite series, some special functions, integral equations, and Laplace and Fourier Transforms. Generalized expansion theorems for differential and difference equations. Application to transient problems in circuits with lumped and distributed parameters, and to ladder networks. Associate Professor MALTI.

489. *Patents.* Elective for seniors and graduate students in Engineering. First term. Credit one hour. One lecture a week. A consideration of the fundamental principles of United States and foreign patents and their relationship to the engineer. Professor BALLARD.

497, 498. *A.I.E.E. Seminar.* Elective for juniors and seniors who are members of the Student Branch of A.I.E.E. Throughout the year. Credit one hour a term. One period each week. Study and practice in the preparation and delivery of professional engineering papers. The organization, conduct, and purposes of the professional engineering societies. Associate Professor STRONG, the Counsellor of Cornell Branch A.I.E.E., and others.

4C53, 4C54. *Ultra-High-Frequency Techniques.* Throughout the year. Credit three hours a term. Two lecture-recitations and one laboratory period a week. Prerequisite course, 450. A study of the theory and techniques of ultra-high-frequency equipment. The course will include both theoretical consideration and laboratory testing of various types of high frequency oscillators including triodes, magnetrons, klystrons and other similar tubes; transmission lines including parallel wire and concentric types; wave guides; radiating systems including antenna arrays, electro-magnetic horns, paraboloids, and other directive systems; receivers for ultra-high-frequency waves; pulse circuits and cathode ray oscillographs. Maxwell's field equations and their application in the theory of ultra high frequency propagation and radiation. Professor BALLARD, Assistant Professor MCLEAN, and instructors.

School of Chemical Engineering

FIVE-YEAR COURSE

Because a competent chemical engineer must be thoroughly familiar not only with the fundamentals of engineering and with the special field of chemical engineering but also with the science of chemistry, it is impossible to provide adequate preparation for professional work in Chemical Engineering in four years. The curriculum leading to the degree of Bachelor of Chemical Engineering outlines an integrated five-year course. Provision is made for a considerable amount of elective work. The elective work may be either in cultural subjects or in fields in which the student desires specialized or advanced instruction.

Here follows an outline of the regular five-year course of study leading to the degree of Bachelor of Chemical Engineering.

		COURSE	HOURS *First Term*	HOURS *Second Term*
FIRST YEAR 37 HOURS	Introductory Inorganic Chemistry	Chemistry 110	3	2
	Inorganic Chemistry Laboratory	Chemistry 115	3	0
	Introductory Qualitative Analysis	Chemistry 203	0	5
	Analytic Geometry and Calculus	Mathematics 60a, b	3	3
	English	English 2	3	3
	Introductory Experimental Physics	Physics 11, 12	4	4
	Drawing	M.E. 3C14, 3C15	2	2
SECOND YEAR 39 HOURS	Introductory Organic Chemistry	Chemistry 305	3	3
	Organic Chemistry Laboratory	Chemistry 310	3	3
	Introductory Quantitative Analysis	Chemistry 220	3	0
	Quantitative Analysis Laboratory	Chemistry 221	3	0
	Gas and Fuel Analysis	Chemistry 250	0	3 or 0
	Elementary Mineralogy	Geology 311	0	0 or 3
	General Physics	Physics 21, 22	3	3
	German	German 1b, c	3	3
	Calculus and Differential Equations	Mathematics 60c, d	3	3
THIRD YEAR 36 HOURS	Introductory Physical Chemistry	Chemistry 405	3	3
	Physical Chemistry Laboratory	Chemistry 410	3	3
	Introductory Chemical Microscopy	Chem. E. 530	0 or 3	3 or 0
	Elementary Mineralogy	Geology 311	3 or 0	0
	Gas and Fuel Analysis	Chemistry 250	0 or 3	0
	Mechanics	M.E. 3M21	5	0
	Strength of Materials	M.E. 3M22a, b	0	5
	Chemical Engineering Technology	Chem.E. 701	2	2
	Materials of Construction	Chem. E. 755	2	2
FOURTH YEAR 35 HOURS	Unit Operations of Chemical Engineering	Chem.E. 705	3	3
	Chemical Engineering Laboratory	Chem.E. 710	2	2
	Advanced Physical Chemistry	Chemistry 420	3	0
	Special Topics in Chemistry	Chem. E. 910	1	0
	Heat-Power Engineering	M.E. 3P33	3	0
	Heat-Power Engineering	M.E. 3P34	0	3
	Mechanical Laboratory	M.E. 3X33	3	0
	Mechanical Laboratory	M.E. 3X34	0	3

	Chemical Engineering Economics	M.E. 3A53	3 or 0	0
	Plant Inspections	Chem.E. 735	0	1
	Electives		0 or 3	6
FIFTH YEAR 34 HOURS	Electrical Engineering	E.E. 407	4	0
	Electrical Engineering	E.E. 408	0	4
	Machine Design, Recitations	M.E. 3D34	2	0
	Machine Design, Drawing	M.E. 3D36	0	1
	Chemical Plant Design	Chem.E. 730	3	3
	Chemical Engineering Computations	Chem.E. 740	2	2
	Chemical Engineering Economics	M.E. 3A53	0 or 3	0
	Electives (hours per term variable)		3 or 6	7

Students who present two or three units of German at entrance may not take the first term of German 1b for credit. Students who present three units of German may, on recommendation of the Department of German, substitute German 8 for the second term of German 1b. The equivalent number of hours of electives will be substituted for the first term of German 1b, in the above cases.

Elective courses may be taken in any college of the University. The selection must be approved by the student's adviser.

If, in the opinion of the faculty of the School of Chemical Engineering, a student's general record is unsatisfactory, the student will be refused permission to continue his work for the degree of B. Chem. E., even though he has met the minimum requirements in respect to the number of hours of work passed and the grades in these hours.

OPTIONS IN CHEMICAL ENGINEERING

A student in Chemical Engineering may, by suitable selection of his elective courses, obtain specialized and intensive training in any one of several optional fields. The completion of an option in one of these specialized fields is not required. The student may, if he so desires, arrange his elective work to provide a cultural background not afforded by courses within the scope of the strictly professional field. The selection of electives must be approved by the class adviser.

The elective courses are normally taken in the fourth and fifth years, although in some instances it may be of advantage to include some of them in the third year.

The available options and the recommended courses in each are listed below. The courses of primary importance are indicated by an asterisk.

ADMINISTRATIVE ENGINEERING

		COURSE	HOURS *First Term*	HOURS *Second Term*
FOURTH YEAR	*Engineering Business Law or	M.E. 3A43	3 or 0	0
	*Engineering Law	C.E. 290	3 or 0	0 or 3
	*Engineering Economy	M.E. 3I48	0	2
	Corporation Finance	Economics 31	0	3
FIFTH YEAR	*Industrial Relations	M.E. 3A49	2	0
	*Public Speaking 1		3 or 0	0 or 3
	Industrial Statistics	M.E. 3A41	0	3
	Principles of Cost Control	M.E. 3A47	0	3

ORGANIC CHEMISTRY

		COURSE	HOURS *First Term*	HOURS *Second Term*
FOURTH YEAR	*Advanced Organic Chemistry	Chemistry 315	2	2
	*Identification of Organic Compounds	Chemistry 340	0	3
FIFTH YEAR	*Special Topics in Organic Chemistry	Chemistry 325	2	2
	Biochemical Aspects of Organic Chemistry	Chemistry 345	0	2
	Physical Aspects of Organic Chemistry	Chemistry 335	2	0
	Advanced Organic Chemistry Laboratory	Chemistry 320	0	4
	Chemistry of Foods and Nutrition	Nutrition 160	2	2
	Unit Processes of Chemical Engineering	Chem. Eng. 715	0	3

PHYSICS

FOURTH YEAR	*Modern Physics	Physics 41, 42	2	2
	*Special Topics in Physics (Laboratory)	Physics 315	2	2
FIFTH YEAR	*Advanced Laboratory Practice	Physics 105	3	3
	Mechanics	Physics 111	3	0
	Properties of Matter	Physics 112	0	3
	Electricity and Magnetism	Physics 121	3	0
	Electricity and Magnetism	Physics 122	0	3
	Light	Physics 132	0	3
	Heat	Physics 142	0	3
	Wave Motion and Sound	Physics 162	0	3
	Special Topics Laboratory	Phy. 320c, d or f	3	3

METALLURGY AND METALLOGRAPHY

THIRD YEAR	*Metal Processing	M.E. 3S11	1 or 0	0 or 1
	*Introductory Metallography	Chem. E. 545	0	0 or 3
FOURTH YEAR	*Introductory Metallography	Chem. E. 545	3 or 0	0
	*Advanced Metallography	Chem. E. 550	0	2
	*Advanced Metallography Laboratory	Chem. E. 550	0	2
	*Advanced Inorganic Chemistry	Chemistry 130	3	0
FIFTH YEAR	*Electrochemistry	Chemistry 450	3	0
	Phase Rule	Chemistry 425	0	3
	Properties of Matter	Physics 112	0	3
	Advanced Laboratory Practice	Physics 105	0	3
	Applied Metallography	M.E. 3X52	2	0

SANITARY ENGINEERING

FOURTH YEAR	*Sanitary Biology	C.E. 250	3	0
	*Sewerage and Sewage Treatment	C.E. 252	0	3
	Treatment of Water	C.E. 253A	0	2
FIFTH YEAR	*Treatment of Wastes	C.E. 255	3	0
	*Sanitary Biology	C.E. 251	0	2
	Water and Sewage Analysis	C.E. 258	2	0
	Laboratory Course for Graduates	C.E. 259	0	3

PHYSICAL CHEMISTRY

FOURTH YEAR	*Chemistry of Solids	Chemistry 435	3 or 0	0
	*Applications of Phase Rule	Chemistry 425	0	0 or 2
	*Introductory Electrochemistry	Chemistry 445	0	3
	*Colloid Chemistry	Chemistry 430	0 or 2	0 or 2

FIFTH YEAR	*Application of the Phase Rule	Chemistry 425	0	2 or 0
	*Applied Electrochemistry	Chemistry 450	3	0
	*Chemistry of Solids	Chemistry 435	0 or 3	0
	*Colloid Chemistry	Chemistry 430	0 or 2	0 or 2
	*Thermodynamics	Chemistry 470	3	3
	Advanced Inorganic Chemistry	Chemistry 130	3	0

FOODSTUFFS

FOURTH YEAR	*Chemistry of Foods and Nutrition	Nutrition 160	2	2
	Advanced Organic Chemistry	Chemistry 315	2	0
	*Biochemical Aspects of Organic Chemistry	Chemistry 345	0	2
	Sewerage and Sewage Treatment	C.E. 252	0	3
FIFTH YEAR	*General Bacteriology	Bacteriology 1	6	0
	*Applied Bacteriology	Bacteriology 103	0	6
	Treatment of Wastes	C.E. 255	3	0

THE COURSES OF INSTRUCTION

Following is a list of the courses of instruction which are prescribed for the course of study leading to the degree of Bachelor of Chemical Engineering. Some of them are given in other schools of the College of Engineering or in other colleges of the University. Those in Chemistry, Physics, English, Mathematics, German, and Geology are given in the College of Arts and Sciences. Those in Mechanics, Strength of Materials, Drawing, Heat-Power Engineering, Mechanical Laboratory, Chemical Engineering Economics, and Machine Design are given in the School of Mechanical Engineering, and those in Electrical Engineering in the School of Electrical Engineering, and any such courses, required or elective, will be found described elsewhere in this Announcement.

CHEMISTRY

110. *Introductory Inorganic Chemistry*. Throughout the year. Credit three hours first term, two hours second term. Prerequisite, entrance credit in chemistry, or course 101. Required of candidates for the degree of Bachelor of Chemical Engineering.

Lectures: Professor LAUBENGAYER. First term, M W F 8; second term, W F 8. *Baker* 200.

115. *Introductory Inorganic Chemistry*. Recitations and laboratory practice. First term. Credit three hours. Must be taken with the first term of Chemistry 110. Deposit, $20. Professor LAUBENGAYER and assistants.

Recitations: one hour a week, to be arranged. Laboratory: to be arranged. *Baker* 50.

203. *Introductory Qualitative Analysis*. Second term. Credit five hours. Prerequisite, one term of Chemistry 110 or special permission. Deposit, $30. Must be taken with the second term of Chemistry 110. Required of students in the course in Chemical Engineering. Professor NICHOLS, Dr. LONG, and assistants.

Lecture or recitation: M 8. *Baker* 200. One other recitation, to be arranged. Laboratory: M W F 1:40–4 or T Th 1:40–4; S 8–10:30. *Baker* 50.

220. *Introductory Quantitative Analysis.* Repeated in the second term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 221. Professor NICHOLS and assistants.

Lectures: T Th 9. *Baker* 207. Recitations: one hour a week, to be arranged.

A study of the fundamental principles of gravimetric and volumetric analysis with practice in stoichiometry.

221. *Introductory Quantitative Analysis.* Repeated in the second term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 220. Deposit, $20. Professor NICHOLS and assistants.

Laboratory sections: F 1:40–4, S 8–1; T Th 10–12:30, Th 1:40–4 (first term only). *Baker* 252.

Laboratory practice in the preparation and standardization of various volumetric solutions and the analysis of a variety of substances by volumetric and gravimetric methods.

250. *Gas and Fuel Analysis.* Either term. Credit three hours. Prerequisite, Chemistry 220 and 221. Fee, $10. Professor NICHOLS and assistants. Lectures: F 10. *Baker* 207.

Laboratory sections: First term, M T 1:40–4; T Th 10–12:30; Th F 1:40–4; S 8–1; Second term, M T 1:40–4; T Th 10–12:30, W Th 1:40–4; S 8–1. *Baker* 282.

The complete analysis of coal gas, flue gas, and air, the determination of the heating power of gaseous, liquid, and solid fuels; the analysis of coal; standard methods of testing various petroleum and coal-tar products; the analysis of various substances by methods involving the use of different types of gas evolution apparatus. Problems are assigned which afford practice in the calculation and interpretation of results.

305. *Introductory Organic Chemistry.* Throughout the year. Credit six hours on completion of the course. Prerequisite, qualitative analysis. Open to those who are taking Course 220. Professor JOHNSON and Dr. MILLER. M W F 9. *Baker* 200.

Lectures and written reviews. The more important compounds of carbon, their occurrence, methods of preparation, relations, and uses.

310. *Introductory Organic Chemistry.* Throughout the year. Credit three hours a term. Prerequisite or parallel course, Chemistry 305. Deposit, $35. Professor JOHNSON, Dr. MILLER, and assistants. Laboratory sections, T Th 10–12:30; Th 1:40–4; F 1:40–4, S 8–1. *Baker* 250.

Laboratory practice and oral reviews. The student prepares a large number of typical compounds of carbon and familiarizes himself with their properties, reactions, and relations.

405. *Introductory Physical Chemistry.* Throughout the year. Credit three hours a term. Prerequisite, Chemistry 305. Mathematics 5a and 5b and Physics 11 and 12 (or their substantial equivalent). Professor BRIGGS and assistants. Lectures, M W F 9. *Baker* 7.

A systematic presentation of modern physical chemistry. The topics include the properties of gases, liquids, and solids; physical and chemical equilibrium in homogeneous and heterogeneous systems; the Mass Law, theorem of Le Chatelier, and the Phase Rule; thermochemistry and elementary thermodynamics; the theory of solutions; ionic equilibria and the con-

cept of activity; chemical kinetics and catalysis; photochemistry; written problems in physical chemistry.

410. *Introductory Physical Chemistry*. Throughout the year. Laboratory and recitations. Credit three hours a term. Prerequisite or parallel course, Chemistry 405. Deposit, $20. Professor BRIGGS and assistants. Laboratory sections: M T 1:40–4; Th F 1:40–4; and S 8–1. *Baker* 1. Recitations to be arranged.

Qualitative and quantitative experiments illustrating the principles of physical chemistry and practice in performing typical physico-chemical measurements. Recitations on the general principles of physical chemistry, based upon the lectures given in Course 405.

420. *Advanced Physical Chemistry*. First term. Credit three hours. Prerequisite, Chemistry 405. Dr. HOARD. Lectures and recitations, M W F 12. *Baker* 7.

Exposition of the principles of physical chemistry from the mathematical standpoint, with emphasis on the solution of simple problems.

For description of other courses in Chemistry, available as electives in the course in Chemical Engineering, see announcement of the College of Arts and Sciences.

PHYSICS

For description of Physics courses 11 and 12, see page 165 of this Announcement. For courses 21 and 22, see page 166 of this Announcement. For advanced courses in Physics available as electives, consult the *Announcement of the College of Arts and Sciences*.

MATHEMATICS

60a, 60b. *Analytical Geometry and Calculus*. Throughout the year. Credit three hours a term. Prerequisites, Solid Geometry and Trigonometry.

60c, 60d. *Calculus and Differential Equations*. Throughout the year. Credit three hours a term. Prerequisite, Mathematics 60a and 60b.

MECHANICAL ENGINEERING

Those courses required for the degree of Bachelor of Chemical Engineering that are given in the School of Mechanical Engineering are described in the section of this announcement that is devoted to a discussion of the work in Mechanical Engineering.

ELECTRICAL ENGINEERING

Courses 407 and 408 in Electrical Engineering are described on page 148 of this Announcement.

ENGLISH

English 2. Throughout the year. Credit three hours a term. May not be entered the second term. The course is a training in reading and writing English. Registration is in charge of Director RHODES, Professor BROWN, and others.

GERMAN

1c. *Course for Chemists: Grammar, Reading of Texts in Chemistry*. Throughout the year. Credit six hours on completion of the course, three hours for those

taking it only the second term. Professor ANDREWS and Dr. MUELLER. M W F 11, 12. *Goldwin Smith* 177, 190.

CHEMICAL ENGINEERING

530. *Introductory Chemical Microscopy*. Repeated in the second term. Credit three hours. Prerequisite, or parallel course, Chemistry 405 or 406 and Physics 21 and 22, or special permission. Fee, $5. Professor MASON and assistants.

Lecture, M 11. *Olin* R.

Laboratory sections, M T 1:40–4; T Th 10–12:30. *Olin* 305.

Lectures and laboratory practice. The use of microscopes and their accessories in chemical and technical investigations. Micrometry; quantitative estimations; microscopical characteristics and physical chemistry of crystals; illumination, ultra-microscopy and photomicrography; study of industrial materials such as textile and paper fibres.

545. *Introductory Metallography*. First term. Credit three hours. Prerequisite or parallel course, Chemistry 405, or Engineering 3X31. Fee, $10. Professor MASON and assistant. Th F 1:40–4; additional M T 1:40–4 section if warranted. *Olin* 312A. Conference or lecture, W 10.

Microstructures of alloys, as related to composition, thermal history, and physical properties and explained in terms of general crystallographic phenomena. Preparation of specimens, and principles and use of metallographic microscopes.

550. *Advanced Metallography*. Second term. Lectures, credit two hours. Laboratory optional, credit one or more hours. Prerequisite Chemical Engineering 545. Laboratory fee variable. Professor MASON, *Olin* R and *Olin* 312A.

565. *Special Methods in Chemical Microscopy*. Either term. Credit one or more hours. Fee variable. Professor MASON. Day and hour to be arranged.

Laboratory practice may be elected in various fields, such as photomicrography, ultramicroscopy, crystal studies, micro-manipulations, quantitative determinations, and the microscopy of industrial materials.

595. *Research*. Either term. Credit two or more hours a term. Fee variable. Professor MASON.

701. *Chemical Engineering Technology*. Throughout the year. Credit two hours a term. Prerequisite or parallel course, Chemistry 405. Professor RHODES. T Th 9. *Olin* A.

Lectures. A discussion of the important chemical engineering processes and industries. The first term is devoted to the consideration of inorganic chemical technology; in the second term the discussion deals with the organic chemical engineering industries.

Required of third-year students in Chemical Engineering.

705. *Unit Operations of Chemical Engineering*. Throughout the year. Credit three hours a term. Prerequisite, Chemistry 405. Professor RHODES. M W F 10. *Olin* A.

Lectures. A critical discussion of the important unit operations of chemical engineering: fluid flow, heat transfer, evaporation, distillation, filtration, gas absorption, crushing, and grinding, etc. In these lectures, particular emphasis is placed on the fundamental theory upon which the various unit operations are based.

710. *Unit Operations Laboratory.* Throughout the year. Credit two hours a term. Prerequisite, Chemistry 405. Fee, $10. Professor RHODES, Associate Professor SWENSON, and assistants. Laboratory period, day and hour to be arranged. *Baker* B-78. Conference period, Th 11. *Olin* B.

The study in the laboratory, on a semi-plant scale, of the unit operations of chemical engineering, such as agitation and mixing, filtration, fractional distillation, evaporation, drying, absorption of gases, and heat transfer.

715. *Unit Processes of Chemical Engineering.* Second term. Credit three hours. Prerequisite or parallel course, Chemical Engineering 705. Associate Professor WINDING. M W F 9. *Olin* B.

725. *Petroleum and Fuel Technology.* First term. Credit three hours. Prerequisite or parallel course, Chemical Engineering 705. Associate Professor WINDING. M W F 9. *Olin* B.

Lectures. The chemistry of coal, coke, petroleum, and the fuel gases. Particular stress is laid upon the theoretical chemistry involved in the distillation and refining of petroleum.

730. *Chemical Plant Design.* Throughout the year. Credit three hours a term. Prerequisite, Chemical Engineering 705. Deposit, $20. Professor RHODES and Associate Professors WINDING and SWENSON. Day and hour to be arranged.

One conference and two laboratory periods. Practice in the calculation and design of chemical plant equipment.

735. *Plant Inspections.* Second term. Credit one hour. Prerequisite or parallel course, Chemical Engineering 705.

Visits to plants typical of various chemical industries. Conferences and reports. A trip during spring vacation will be a feature of this course. Fee, covering expenses, to be announced.

The schedules of plant visits are so arranged that a different group of plants is visited each year, over at least a three-year cycle. All students in Chemical Engineering are required to make at least one of the inspection trips.

740. *Chemical Engineering Computations.* Throughout the year. Credit two hours. Prerequisite or parallel course, Chemical Engineering 705. Associate Professor WINDING. T Th 10. *Olin* B.

Conferences and lectures. Problems in stoichiometric relationships, material balances and reaction rates, fluid flow and heat transfer, distillation, evaporation and drying, humidification and air conditioning, and filtration.

755. *Materials of Construction.* Throughout the year. Credit two hours a term. Prerequisite or parallel course, Chemistry 405. Professors MASON, RHODES, and Associate Professor WINDING. W F 11. *Olin* R.

Lectures. A discussion of the nature, behavior, and application of the important structural materials used in chemical engineering: metals and alloys, cement and concrete, ceramic materials and refractories, plastics, protective coatings, etc.

Required of third-year students in Chemical Engineering.

760. *Chemical Engineering Instrumentation.* Second term. Credit two hours. Prerequisite or parallel course, Chemical Engineering 705. Mr. KRANICH. T Th 12. *Olin* B.

Lectures. Basic principles of instrumentation and process control. Applications of automatic indicating, recording, and controlling instruments in the process industries. Description of commercial types of instruments.

795. *Research for Seniors.* Throughout the year. Credit two or more hours a term. Fee variable. Professor RHODES and Associate Professors WINDING and SWENSON.

910. *Library Use and Patents.* First term. Credit one hour. Professors RHODES and MASON. T 11. *Olin* B.

The effective use of technical literature; literature searches; abstracts and bibliographies; patent law.

General Courses of Instruction

Described in this section are certain University courses that fall outside the jurisdiction of any college, courses in the College of Engineering that fall outside the jurisdiction of any one of the four Schools, and courses in the College of Arts and Sciences prescribed for students in engineering. Courses of instruction given by each of the four Schools of the College of Engineering are described above, under the appropriate heading.

ENGINEERING

1J31, 1J32. *Engineering Journalism.* Elective for Juniors who are members of the staff of *The Cornell Engineer.* Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours. Practical training in magazine editing and business management, including the writing of technical articles, copy reading, proof reading, makeup, and other editorial procedures; also accounting, advertising, the handling of circulation problems, and other phases of business management as related to publishing. Group meetings and individual conferences at hours to be arranged. Assistant Professor THATCHER and Mr. HOWES.

1J41, 1J42. *Engineering Journalism.* A continuation of 1J31, 1J32. Elective for Seniors who are members of the staff of *The Cornell Engineer.* Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours.

GENERAL UNIVERSITY COURSES

HYGIENE

1. *Hygiene.* First term. Credit one hour. Required of all freshmen. One lecture-recitation each week, with preliminary examination and final. The use of a text-book will be required. Special sections provided for those contemplating Military service.

Students must report for registration and assignment to section at *Barton Hall.*

Sections for men: Professor SMILEY, Assistant Professors GOULD and SHOWACRE.

Sections for women: Assistant Professors EVANS and STELLE.

2. *Hygiene.* Second term. Credit one hour. Required of all freshmen. One lecture-recitation each week, with preliminary examination and final. The use of a text-book will be required. Special sections provided for those contemplating Military service. Sections will be provided in the first term as well as in the second term.

Students must report for registration and assignment to section, the men at the *Old Armory*, the women at *Sage Gymnasium.*

Sections for men: Professor SMILEY, Assistant Professors GOULD and SHOWACRE.

4. *Advanced First Aid.* First and second term. Credit two hours. Assistant Professor SHOWACRE. Anatomy lecture room, *Stimson*, F 9, and one evening

practice session a week. Registration at Hygiene Office, *Old Armory*. Prerequisites: Hygiene 1 and 2.

This course will include a discussion and practical demonstration of the main methods at hand for preventing accidents and for giving emergency treatment. This course should lead to certification with the Red Cross for both Standard and Advanced First Aid.

5. *Industrial Hygiene.* First term. Credit two hours. Assistant Professor GOULD. T Th 12. Histology lecture room, *Stimson*. Registration at Hygiene Office, *Old Armory*. Prerequisites: Hygiene 1 and 2.

Factory sanitation, ventilation, and illumination; occupational poisoning and disease; factory legislation; accident prevention; fatigue in industry; preventive medicine in the industries.

7. *Military Preventive Medicine.* Second term. Credit two hours. (Prerequisites, Military Science and Tactics Basic Course 1.) T Th 12. *Stimson* G 1. Dr. DEYOE. (Not given in 1942–43).

A study of the principles of military hygiene and sanitation as applied to permanent and temporary military camps.

8. *Hygiene: Mental Hygiene.* First or second term. Credit three hours. First term, *Stimson*. M W F 11. Assistant Professor STELLE. Second term, *Stimson*. M W F 11. Assistant Professor DARLING. Registration at Hygiene Office, *Old Armory*.

The relationship of the structure of the total personality to environmental maladjustment as evidenced by physical and social behavior; a discussion of the more common personality difficulties and the role of insight in the prevention of these.

MILITARY SCIENCE AND TACTICS

1. *Basic Course.* Required. Throughout the year. The complete course covers two years. Three hours a week, either M T W Th or F 1:40–4:10 P.M.

The course of training is that prescribed by the War Department for Senior Division Units of the Reserve Officers Training Corps for basic students. Instruction is offered in Field Artillery and Signal Corps. For details concerning the course see the Announcement of the Department of Military Science and Tactics.

Required of all able bodied first and second year male students who are American citizens and candidates for a baccalaureate degree. The requirements of Military Science and Tactics must be completed in the first terms of residence; otherwise the student will not be permitted to register again in the University without the consent of the faculty.

Advanced standing: With the approval of the Department of Military Science and Tactics, credit may be allowed a student for all or part of the Basic Course requirement, upon presentation of evidence of satisfactory work completed at an approved institution.

2. *Advanced Field Artillery Course.* Elective. Two lectures and three hours of leadership a week throughout the entire course of two years, and in addition attendance at a Summer Training Camp of three months duration. Credit one hour each term, except for Chemical Engineers. Prerequisite course, Basic Field Artillery Course. First year covers military fundamentals, reconnaissance and occupation of position, leadership, gunnery, transport, and military motor vehicles. Second year course covers military fundamen-

tals, leadership, tactics, and field artillery subjects. Hours by assignment. *Barton Hall.*

3. *Advanced Signal Corps Course.* Elective. Three lectures and one hour of leadership a week throughout the entire course of two years, and in addition attendance at a Summer Training Camp of 3 months duration. Credit one hour each term, except for Chemical Engineers. Prerequisite courses, Basic Signal Corps Course and Physics 21. Concurrent courses Elements of Electrical Engineering 411, 412, or Fundamentals of Electrical Engineering 405, 406 or Principles of Electrical Engineering 415, 416. Courses E.E. 451, 452, 453 desirable but not required. First year covers military fundamentals, leadership, signal communication, and tactics. Second year covers military fundamentals, leadership, and training management. Hours by assignment. *Barton Hall.*

4. *Advanced Ordnance Course.* Elective. Two lectures and one hour of leadership a week, plus an additional ten hours classroom work each year throughout the entire course of two years, and in addition attendance at a Summer Training Camp of three months duration. Credit one hour each term, except for Chemical Engineers. Prerequisite courses Basic Field Artillery Course of Basic Signal Corps Course. Open only to students in the College of Engineering. Lectures for the first year of the course are Ordnance problems 3M53; see description on page 128. Second year covers military history, property and emergency procurement, military law, ordnance field service, and leadership.

* * *

These courses of training are those prescribed by the War Department for Senior Division Units of the Reserve Officers Training Corps, for advanced students. For details concerning the courses see the Announcement of the Department of Military Science and Tactics.

Upon successful completion of the advanced course and the Summer Training Camp a student may be commissioned as a Reserve Officer of the United States Army, in the appropriate arm or service, upon the recommendation of the Professor of Military Science and Tactics.

ARTS AND SCIENCES

ASTRONOMY

For courses 182, 183, and 186, see pages 73–74.

CHEMISTRY

Entrance credit in chemistry does not carry with it University credit in Courses 102 *or* 104. *If a student entering the University from a preparatory school desires credit for these courses, he must pass an examination set by the Department of Chemistry. This examination is held in Ithaca on the same day in September as the entrance examination. University credit in Courses* 104*a and* 104*b that is obtained by passing this examination does not carry with it entrance credit in Chemistry.*

Chemistry 102. Throughout the year. Credit three hours a term. First term prerequisite to second. Open only to those students who do not offer entrance chemistry. Deposit, $11 each term. Professor BROWNE, Professor LAUBENGAYER, Dr. TAUBE, and assistants. Lecture: Th or F 11, *Main Lecture Room,*

Baker. Recitation: one hour a week, to be arranged. Laboratory: one 2½-hour period, to be arranged.

This course deals with the fundamental laws and theories of chemistry and the properties of the more common elements and their compounds.

Chemistry 104. Throughout the year. Credit three hours a term. First term prerequisite to second. Open to those students who offer entrance chemistry. Deposit, $11 each term. Professor PAPISH, Dr. ———, and assistants. Lecture: M 11, T 9, or T 11, *Main Lecture Room, Baker*. Recitation: one hour a week, to be arranged. Laboratory: one 2½-hour period, to be arranged.

This course deals with the fundamental laws and theories of chemistry and the properties of the more common elements and their compounds.

For other courses, see page 156.

ECONOMICS

For courses 3, 11, and 31, see page 72.

ENGLISH

For course 2, see pages 72, 117, 147, and 158.

GEOLOGY

501. *Engineering Geology*. See page 72.

GERMAN

1c. Course for Chemical Engineers See page 158.

MATHEMATICS

55a. *Analytical Geometry and Calculus*. First term. Credit five hours. Repeated in second term.

55b. *Analytical Geometry and Calculus*. Second term. Credit five hours. Given also in first term.

Course 55a or 55b may not, without special permission, be taken simultaneously with any of the other courses in Mathematics. Courses prerequisite to 55a or 55b are Advanced Algebra or Solid Geometry, and Trigonometry.

For courses 60a, 60b and 60c, 60d, see page 158.

PHYSICS

Physics 11. Introductory Experimental Physics. Required of Freshmen Engineering students. First term. Credit four hours. Prerequisites, Calculus or simultaneous registration in Mathematics 55a, 65b, or 60a. Entrance physics desirable but not required. Two demonstration lectures, two recitations, and one laboratory period a week. Theory, problems, and laboratory practice in mechanics, wave-motion, sound, and heat. Laboratory fee, $5. *Rockefeller Hall*. Professor GRANTHAM, Assistant Professor TOMBOULIAN, and assistants.

Physics 12. Introductory Experimental Physics. Required of Freshmen Engineering students. Second term. Credit four hours. Prerequisites, Calculus or simultaneous registration in Mathematics 55a, 65b, or 60a. It is recommended, though not required, that Physics 11 precede this course. Two demonstration lectures, two recitations, and one laboratory period a week.

Theory, problems, and laboratory practice in electricity, magnetism, and light. Laboratory fee, $5. *Rockefeller Hall.* Professor GRANTHAM, Assistant Professor TOMBOULIAN, and assistants.

Physics 21. Required of candidates for the degrees of B.M.E., B.E.E., or B.Chem.E. First term. Credit three hours. Prerequisites, Physics 11, and Differential and Integral Calculus, and a passing grade in Physics 12. Two recitations a week and one laboratory period on alternate weeks. Theory, problems, and laboratory practice covering selected topics in electricity and magnetism. Laboratory fee, $2.50. Professor GRANTHAM, Assistant Professor TOMBOULIAN, and others.

Physics 22. General Physics. Required of candidates for the degrees of B.M.E., B.E.E., or B.Chem.E. Second term. Credit three hours. Prerequisites, Physics 11, and Differential and Integral Calculus, and a passing grade in Physics 12. Two recitations a week and one laboratory period on alternate weeks. Theory, problems, and laboratory practice in electronics, photoelectricity, photometry, kinetic theory, radiation, polarized light, interference, and diffraction. Laboratory fee, $2.50. Professor GRANTHAM, Assistant Professor TOMBOULIAN, and others.

Physics 41. Modern Physics. Elective. First term. Credit two hours. Prerequisites, Physics 21 and 22. Two recitations a week, T Th 10. For students of engineering who desire a knowledge of the more recent theories and applications of modern physics. Discussion and problems covering those aspects of sound, electrodynamics, electron optics, and kinetic theory of gases which are of importance in modern development of engineering. Professor SMITH.

Physics 42. Special Topics in Modern Physics. Second term. Credit two hours. Prerequisites, Physics 21 and 22. Two recitations a week, T Th 10. For students of engineering who desire a knowledge of the more recent theories and practices of modern physics. Discussion and problems covering those aspects of quantum theory, electrons in solids, thermionic emission, secondary emission, atomic structure and radiations, conduction of electricity in gases, and nuclear structure and radiations which are of special interest to the engineer. Professor SMITH.

PUBLIC SPEAKING

Public Speaking 1. Repeated in second term. Credit three hours. Planned to give the fundamentals of speech preparation and to develop simple and direct speaking. Study of principles, and constant practice; readings on public questions; conferences; drills. Fee for materials, $2. Professor WICHELNS, Associate Professor WAGNER, Assistant Professor MUCHMORE, and Messrs. DEBOER, MOUAT, and HUNTER.

Foreign students and others whose pronunciation of English falls below the normal standard, and students with special vocal problems, are advised to confer with Assistant Professor THOMAS before registering for course 1.

Index

THE COLLEGE OF ENGINEERING
CORNELL UNIVERSITY

Announcement of Accelerated Programs

Leading to Degrees

in

Civil, Mechanical, Electrical, Chemical,
and Administrative Engineering

Supplement

BEGINNING—JUNE, 1942

VOLUME 33 : FEBRUARY 15, 1942 : NUMBER 13

COLLEGE OF ENGINEERING CALENDAR

ACCELERATED PROGRAM

Summer Terms

Present Students	
Registration	May 29–30
Instruction period	June 1 to September 12
New Students	
Registration	June 29
Instruction period	June 30 to September 12

First Semester

Freshman week begins	September 25
Registration – new students	September 28–29
Registration – old students	September 29
Instruction begins	October 1
Thanksgiving Recess	November 26
Christmas Recess	December 20 to January 3
Examinations	January 21–28

Second Semester

Registration	January 29–30
Instruction begins	February 1
Spring Recess	March 28 to April 4
Examinations	May 17–22
Commencement Day	May 24

Additional Summer Sessions

(For information consult Director, Summer Session)

May 25–June 27	First 5-week Summer Session
June 29–August 8	6-week Summer Session
August 10–September 12	Second 5-week Summer Session

THE ACCELERATED PROGRAM IN ENGINEERING

CORNELL UNIVERSITY

The College of Engineering, recognizing the urgent need for more well-trained engineers in the armed forces and in the war industries, has formulated a plan which will shorten by one year the time usually spent between entrance and graduation. This has been accomplished by providing a third fifteen-week term each summer. Thus, a program which is to supplement the regular four-year and five-year courses with three-year and four-year curricula is made possible without impairing academic standards. The College is also aware that each student, with the advice and assistance of his parents, must work out his own problems in the light of financial and other considerations. The College of Engineering, therefore, does not require any student to take the accelerated program but offers it to those who are able to take advantage of it. It is requested that each student consider this program seriously on the basis of the facts here presented and reach a definite decision to which he is willing to adhere during the time he remains in the University.

GENERAL FEATURES OF THE PLAN

In general, the Accelerated Program, by providing three 15-week terms during each calendar year, offers a student in a regular four-year course the opportunity to graduate in three calendar years, and the student in a regular five-year course the opportunity to graduate in four years. Each student will spend one summer term not in University attendance but under the supervision of his School doing practical work in the field or in industry or, if he is enlisted in an officer-training program that requires it, in military service. This summer of practical experience will normally be the second in the accelerated four-year program and the third in the accelerated five-year program. In other words, each student, whichever accelerated program he selects, will spend two summers taking regular engineering courses and one summer in the field.

Prospective freshmen can enter either on June 29 for an eleven-week term or on September 25, 1942. Entrance in June will give the student the opportunity to take some of his regular courses in advance and therefore lighten the load to be carried during subsequent terms. Whether he enters in June or September, he would graduate from the accelerated course in September, 1945, in Civil, Mechanical and Electrical Engineering, and in May, 1946, in Chemical Engineering. Students not taking the accelerated program will pursue the normal curricula as set forth in the *Announcement of the College of Engineering.*

The accompanying chart shows when a prospective student taking an accelerated program in any one of the four schools will be in attendance. It also shows the modification of this schedule arranged for present students in each year.

	1942		1943			1944			1945			1946
Term	Sum.	Fall	Sprg.	Sum.	Fall	Sprg.	Sum.	Fall	Sprg.	Sum.	Fall	Sprg.
Civil Engineering												
Present Juniors	*	*										
Present Sophomores	S & Ind.	*	*	*	*							
Present Freshmen	*	*	*	S & Ind.	*	*	*					
Prospective Freshmen	Opt.	*	*	*	*	*	S & Ind.	*	*	*		
Mechanical Engineering												
Present Juniors	*	*										
Present Sophomores	*	*	*	*								
Present Freshmen	*	*	*	Ind.	*	*	*					
Prospective Freshmen	Opt.	*	*	*	*	*	Ind.	*	*	*		
Electrical Engineering												
Present Juniors	Ind.	*	*									
Present Sophomores	*	*	*	*								
Present Freshmen	*	*	*	Ind.	*	*	*					
Prospective Freshmen	Opt.	*	*	*	*	*	Ind.	*	*	*		
Chemical Engineering												
Present 4th yr. students	Ind.	*	*									
Present Juniors	Ind.	*	*	Ind.	*	*						
Present Sophomores	*	*	*	*	*	*						
Present Freshmen	*	*	*	*	*	*	Ind.	*	*			
Prospective Freshmen	Opt.	*	*	*	*	*	*	*	*	Ind.	*	*

*—In Attendance S—Summer Camp Ind.—Industrial Employment Opt.—Optional 11-Week Term

TUITION

The student who enrolls in an accelerated program will pay tuition and fees as outlined in the Announcement of the College of Engineering for the regular fall and spring terms. In addition, he will pay tuition for two fifteen-week summer terms at the rate of $200 a term plus required fees. As he will graduate one year earlier, the total expense will remain the same as for the normal program. A freshman electing the optional eleven-week term will pay $120 tuition for that period. Hence the financial problem for a student in the accelerated program is for the most part one of meeting the total college expenses within a shorter time. It is of course recognized that the accelerated program reduces the possibility of full-time summer employment.

PROVISIONS FOR FINANCIAL AID

To help solve the financial problem, the College and University have arranged for the regular payment of John McMullen Regional and Industrial Scholarships through the summer terms spent in the University. Holders of State Cash and Tuition Scholarships who elect the accelerated program will have their scholarship payments accelerated at the same rate so that they will receive scholarship aid for eight terms, even though the total period between entrance and graduation is less than four years. In addition to these adjustments of existing scholarships, the College of Engineering has set up a number of John McMullen War Scholarships at the rate of $100 each term for students in the accelerated program who would be dependent upon their summer earnings. Also the loan funds of the University are available to summer term students, and opportunities for student employment in Ithaca will continue throughout the year.

Each student should apply to the Director of his School for specific information concerning provisions for scholarships and loans if he is in need of financial aid.

THE ACCELERATED PROGRAM AND SELECTIVE SERVICE

Cornell University has not hesitated to request deferment for engineering students in good standing who are subject to call under the Selective Service Act. The College of Engineering believes that the need for engineers in the war program is, and will continue to be so urgent that competent students who are seriously working to prepare themselves for professional work in engineering should be permitted to remain in the College of Engineering until they complete their training. The authorities charged with the administration of the Selective Service Act have generally concurred in this opinion and have been very cooperative in granting deferment to those men who are seriously and effectively pursuing their training in the College. The specific conditions under which the College is in a position to request deferment are determined by rulings of

the Selective Service System and are, of course, subject to change from time to time.

It is possible, however, that some of the local boards may hold that a student who, in these critical times, interrupts his university course for no really urgent reason and prolongs the period of preparation for professional work merely is providing for himself several periods of summer employment not seriously or effectively related to his program of training.

On the other hand, the College believes that a student who, during the summer months, does useful, sub-professional work in any war industry is making a contribution to the war effort and also to the extent and effectiveness of his preparation for technical work. The College would not consider that a student who does serious work in a war industry is unjustifiably interrupting his education and delaying his preparation for technical service, and it assumes that most Selective Service Boards will adopt the same point of view.

THE ACCELERATED PROGRAM AND MILITARY TRAINING

Many students in the College of Engineering are now enlisted in officer-training programs, such as advanced Army R.O.T.C. courses, the Naval Reserve's V–7, and V(S) programs and the Marine Corps' Candidates Class for Officers Training, under which men may be allowed to complete their engineering courses before being called to active duty with the armed forces. It is expected that more men with the necessary physical, intellectual, and moral qualities will qualify for these officer-training programs.

There has as yet been no requirement from the Army or Navy that these students accelerate their academic work, although it is quite evident that officers are needed at the earliest possible moment. The R.O.T.C., to take advantage of the accelerated program, has made plans to operate on a year-around basis and has eliminated the required summer camp before graduation.

THE RELATION TO PHYSICAL EDUCATION AND ATHLETICS

In order that students taking the accelerated program may obtain the maximum advantages from physical education and intercollegiate competition in sports, the Department of Physical Education and Athletics will, during the emergency, admit Freshmen to all Varsity teams. The Department has arranged special year-around schedules of sports.

SUMMARY

The accelerated program in the College of Engineering, as outlined above, has the following general features:

1. It does not involve any decrease in the amount or quality of instruction.

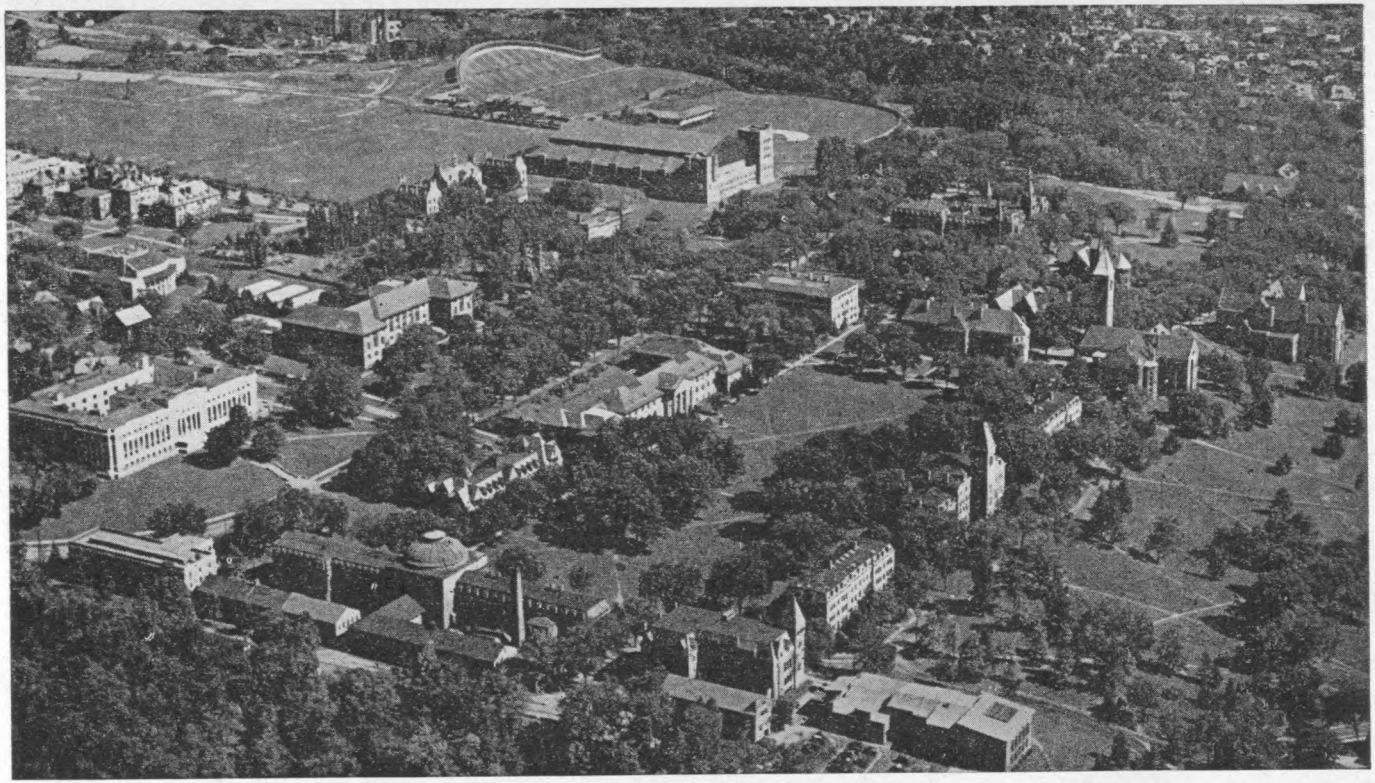
2. The student can advance his professional training more rapidly.

3. The accelerated program does not involve any increase in the total cost of the university education (unless the student elects to enter the Freshman class in June), but it does require that this cost be met in a somewhat shorter period. However, the student is justified in taking greater loans, if necessary, because he is able to engage in productive earning a year sooner. To help meet this more rapid demand for tuition and living expenses, the University will pay scholarship stipends during all terms in which the student is in residence and will provide special loan funds from which a really needy student may borrow.

4. Although the work will be concentrated and will require serious and effective effort on the part of the student, it will not impose any undue strain on one who knows how to organize his work and to make the most of his time.

ADDITIONAL INFORMATION

Additional information concerning any phase of the accelerated program may be obtained from the Dean of the College of Engineering or from the respective Directors of the Schools of Civil, Mechanical, Electrical, and Chemical Engineering. Questions regarding admission to the College should be addressed to the Director of Admissions, Morrill Hall.



THE MAIN QUADRANGLE AND SOME OF THE OTHER PRINCIPAL BUILDINGS OF CORNELL UNIVERSITY

In the foreground and left center are the Engineering group and the laboratories of Chemistry and Physics. In the background are the playgrounds and football and baseball fields. The camera has missed the men's dormitories and other buildings on the right and a large part of the campus on the left. Also the picture does not show the recently completed Olin Hall of Chemical Engineering, one of the largest buildings on the campus.